Growth and yield of black spruce ecosystems in the Ontario Clay Belt: Implications for forest management

T.W. Whynot and M. Penner
Petawawa National Forestry Institute • Information Report PI-X-99

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GROWTH AND YIELD OF BLACK SPRUCE ECOSYSTEMS IN THE ONTARIO CLAY BELT: IMPLICATIONS FOR FOREST MANAGEMENT

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ABSTRACT

Fifty years of permanent sample plot growth information from the Clay Belt Region of Northern Ontario were analyzed. Operational groups (OG's) defined by the Forest Ecosystem Classification (FEC) system for the Clay Belt were compared on the basis of productivity (black spruce (*Picea mariana* [Mill.] B.S.P.) site index at age 50) and grouped into broad productivity classes. An alternate approach, comparing the OG's on the basis of their site index curve shape, did not appear to be an improvement over the first method and was not pursued. The advantages of using the FEC system for forest productivity studies are that it is an objective classification scheme and is used for silvicultural decision making. The disadvantage is that the system is not based on forest productivity and may not be the best classification for growth and yield predictions.

Local black spruce volume tables and stand volume curves were developed based on these classes. Productivity class I volumes peaked earlier and declined at a younger age than other classes and preliminary results indicate volume decline is strongly related to black spruce top height. Mixed stands generally produced slightly more volume than pure black spruce stands on similar sites.

A comparison of cut-origin versus fire-origin stands revealed that post-harvest stands have substantially lower black spruce but higher balsam fir (*Abies balsamea* [L.] Mill.) volumes, indicating that volume curves developed for old growth stands are not suitable for cut stands. Examination of two noncommercially thinned old growth stands at age 80 (approximately 40 years after treatment) revealed no measurable benefit from thinning.

RÉSUMÉ

On a analysé les renseignements qui ont été recueillis sur la croissance à des parcelles-échantillons permanentes dans la Zone d'argile de l'Ontario, pendant les derniers 50 ans. Des Groupes opérationnels (GO) définis par la Classification des écosystèmes forestiers (CEF) pour la Zone d'argile ont été comparés du point de vue de la productivité (épinette noire (*Picea mariana* [Mill.] B.S.P.), indice de station à l'âge de 50 ans) et réunis dans de grandes classes de productivité. Une deuxième approche, la comparaison des Groupes opérationnels en ce qui concerne les formes de courbes des indices de station, ne semblait pas meilleure que la première et elle a été interrompue. L'avantage du système de CEF, quant à la productivité forestière, est que la classification s'avère objective et elle est utilisée lors des prises de décision. L'inconvénient du système est qui'il ne se repose pas sur la productivité forestière elle-même et qu'il ne semble pas être la meilleure classification en matière de croissance et de possibilité.

Les tables de volume de l'épinette noire locale ainsi que les courbes de volume des peuplements ont été dressées en se fondant sur ces classes. Les volumes de la classe I de productivité ont atteint leur maximum plus tôt et décliné à un âge moins avancé que les autres classes. Les résultats préliminaires indiquent aussi que le déclin est étroitement lié à la hauteur dominanante de l'épinette noire. En général, les volumes des peuplements mixtes étaient légèrement plus élevés que les peuplements composés uniquement d'épinette noire, sur des sites similaires.

La comparaison entre les peuplements qui sont nés après une coupe et ceux qui sont nés après un incendie a révélé que les premiers comprenaient, de façon prononcée, des volumes moins élevés de l'épinette noire, mais des volumes plus élevés du sapin baumiers (*Abies balsamea* [L.] Mill.). Ce phénomème veut aussi indiquer que les courbes de volumes qui sont dressées pour les peuplements vièrges ne conviennent pas aux peuplements qui sont nés après une récolte. Deux études ont démontré que la coupe éclaircie effectuée dans un peuplement vièrge de 80 ans (40 ans après le traitement) ne donnait pas de gain mesurable.

Addendum and Errata: **Whynot, T.W. & Penner, M. (1990).** Growth and yield of black spruce ecosystems in the Ontario Clay Belt: Implications for forest management. Forestry Canada, Information Report PI-X-99.

Since publication an omission and a number of errors have been identified; these are listed below.

Addendum.

p.5. Section 4.1.

The general form of the equation is:

$$h = \beta_0(1 - \alpha_1 \text{ age})\left[1 - e^{-\beta_1(1 + \alpha_2 \text{ age}) \text{ dbh}}\right]^{(1 - {}^1\beta_2)}$$

(The above equation was inadvertently omitted)

Errata.

1/. In Table 5, the caption should express units of MAI as: MAI (m^3 ha^{-1} $year^{-1}$).

2/. Please read the labels for the tables and Appendix 1 as 'yield' (not 'volume') tables.

3/. The legend for Figures 5(b)-(f) and 6(b)-(e) is incorrect, but the legend for Figs. 5(a) and 6(a) is correct. The legend should read as for Figs. 5(b)-(f) and 6(b)-(e):

.....	all species
- - - - -	aspen
———	balsam
— — —	birch
-.-.-.-.-	black spruce
-...-...-	jack pine

4/. Please ignore the data in Appendix 2 and Appendix 3.

If any further clarification is requited please contact:

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1.0 INTRODUCTION

1.1 Background

Other black spruce studies

Black spruce (*Picea mariana* [Mill.] B.S.P.) is the most important commercial species in the Clay Belt Region of Northern Ontario (Smith et al. 1987, Arnup et al. 1988). Although there is a substantial amount of growth and yield information available for the Clay Belt Region (Jameson 1953, Evert 1970, 1975, Payandeh 1978, Plonski 1960, Smith 1984), very little of it is compatible with the Forest Ecosystem Classification (FEC) system (see Jones et al. 1983) developed by the Ontario Ministry of Natural Resources, and most studies were not conducted at a scale suitable for operational planning (Hambly 1981).

Black spruce growth and yield estimation using Plonski's yield tables and FRI

Estimation of black spruce growth and yield in the Clay Belt region has traditionally been based on the normal yield tables and site classes developed by Plonski (1960). These are compatible with the Ontario Provincial Forest Resource Inventory (FRI), but not with the FEC and have generally been recognized as being inadequate. Studies by Payandeh (1978) and Smith (1983) indicate that Plonski's yield tables overestimate height and volume on the more productive peatland sites. Although in some cases FRI is useful for providing estimates of current stand volumes and for yield prediction if linked with Plonski's yield tables (Williams 1987), Plonski's curves were developed for a very broad area (Ontario) and lack association with the ecological classification system. Also, the ecological conditions prevailing in the Clay Belt are distinct from the rest of the province (Ray, unpubl. ms.).

Limits to the use of FRI for management

The FRI site classification system has other drawbacks which limit its usefulness for management purposes. First, current harvest yields from overmature stands are not well correlated with the FRI site class because the stands are often harvested after maximum volume is attained and after the onset of significant mortality (Williams 1987). Second, there are often significant site differences in the shape of height-age curves and one site may pass through two or more site classes during its rotation. Finally, current management prescriptions are related to site or ecosystem type as opposed to site class.

Initiation of this study

This study was initiated to examine alternatives to the use of Plonski's tables and FRI for growth and yield prediction by using the recently developed FEC and the extensive database of the Spruce Falls Power and Paper Company Ltd. (SFPP). SFPP has been collecting data from permanent sample plots (PSP's) on their limits since the 1930s. Recently, a large portion of these plots have been classified according to the FEC for the Clay Belt (see Table 1 for a brief description of each operational group in the FEC). This is the most comprehensive PSP data base in the Clay Belt and, therefore, represents an unique opportunity to develop more realistic "local" growth and yield information.

1.2 History of Forest Operations on the Gordon Cosens Forest

Description of the management area

SFPP submitted its first management plan in 1949*, signed forest management agreement No. 500600 in 1980 (applicable to the Gordon Cosens Forest), and prepared a management plan in 1982 covering the period 1980-2000. The Gordon Cosens Forest contains a productive forest of 1 386 000 hectares with spruce the dominant species on 1 million hectares (Table 2). Examination of the age class structure indicates that the forest is predominantly overmature (Table 3). Thus, yield projections of overmature stands are critically important to SFPP be ause the company needs a sustainable wood supply and must know when mortality starts to cause significant volume loss (Hambly 1981). In this report, the term "old growth" will be used to refer to stands with no harvesting history. Stands following harvesting will be referred to as "second growth".

Harvest history

A brief history of harvesting methods is outlined below because many of the stands in this study were harvested several decades ago, at a time when harvesting methods differed from current practices. To a certain extent this change in harvesting practice limits the usefulness of the data, but there are many second growth stands of this type currently within the limits. Also, in some cases, the effect of current harvesting methods on certain sites may be quite similar to that of horse logging.

Horse logging

Walkom (1939) indicated that many early regeneration problems (prior to 1960) were caused by horse logging slash piles covering the seedbeds. However, by the mid- to late 1950s the use of horses in logging was rare and the last horse logging activity dates back to 1965 (Smith 1983, Barrett 1988).

The advent of wheeled skidders

By 1962, SFPP had seven tracked Nodwell Skidders, but began to experiment with wheeled skidders, which became common after 1965. However, by 1975 it became evident that wheeled skidding caused three problems: there was deterioration of lowland sites because of damage to advance regeneration, soil was compacted leading to impeded drainage, and surface organic matter was disturbed to a greater extent than previously*. This led to the use of high flotation tires and a concentra-

*Spruce Falls Power and Paper Ltd. 1982. Spruce Falls Power and Paper Company Ltd. Twenty-Year Management Plan for the Gordon Cosens Forest - 1980-2000. Kapuskasing, Ontario (on file with the OMNR, Timmins, Ont.)

*K. Virgo, pers. comm.

Table 1. The operational groups in the Forest Ecosystem Classification for the Clay Belt (from Jones et al. 1983)

OG1	VERY SHALLOW SOIL OVER BEDROCK	Sb &/or Pj - Feathermoss - Lichen on shallow soil
OG2	VACCINIUM	Pj (&Sb) - *Vaccinium* - Feathermoss - Lichen on dry or fresh sandy soil
OG3	DIERVILLA	Hardwood/Mixedwood - *Vaccinium* - *Diervilla* - Herb poor on fresh sandy or loamy soil
OG4	FEATHERMOSS - COARSE SOIL	Sb (&/or Pj) - Feathermoss on fresh-moist sandy or coarse loamy soil
OG5	FEATHERMOS3 - FINE SOIL	Sb (&/or Pj) - Feathermoss on fresh-moist fine loamy-clayey soil
OG6	LYCOPODIUM	*Lycopodium* - Herb poor on fresh-moist loamy soil
OG7	MIXEDWOOD - HERB RICH	Hardwood/Mixedwood - Herb rich on fresh-moist fine loamy-clayey soil
OG8	FEATHERMOSS - SPHAGNUM	Sb - Feathermoss - Sphagnum on moist fine loamy-clayey soil with 20-39 cm organic matter
OG9	CONIFER - HERB/MOSS RICH	Conifer Mixed - Herb rich on moist fine loamy-clayey soil
OG10	HARDWOOD - ALNUS	Hardwood - *Alnus* - Herb rich on moist fine loamy-clayey soils with thick black organic-mineral forest humus form
OG11	LEDUM	Sb - *Ledum* on wet moderately decomposed organic soil with thick surface fibric horizon
OG12	ALNUS - HERB POOR	Sb - *Alnus* - Herb poor on wet moderately decomposed organic soil with thick surface fibric horizon
OG13	ALNUS - HERB RICH	Sb (&/or Ce/L) - *Alnus* - Herb rich on wet well decomposed organic soil with thin surface fibric horizon
OG14	CHAMAEDAPHNE	Sb - *Chamaedaphne* on wet poorly decomposed organic soil with thick surface fibric horizon

Table 2. The species mix of productive* forest land in the Gordon Cosens Forest (source: SFPP)

Working Group‡	Productive Area (ha)
Pinus strobus	137
Pinus banksiana	46 772
Picea species	999 426
Abies balsamea	44 692
Other conifers	341 764
Populus species	235 026
Other hardwood	7
TOTAL**	1 385 433

*Includes site class IV and not sufficiently restocked areas
‡"Working group" refers to the dominant species by basal area
**Numbers may not add up to the total due to rounding

Table 3. The age class structure of the productive†† forest land in the Gordon Cosens Forest (source: SFPP)

Working Group	Area (ha)						
	Age Class						
	FTG-20	21-40	41-60	61-80	81-100	101-120	120+
White pine							137
Jack pine	1162	1697	12 153	14 752	8728	2546	137 1265
Jack pine	1162	1697	12 153	14 752	8728	2546	1265
Spruce	7023	9012	32 334	61 693	86 070	181 545	380 774
Balsam fir	1795	8501	10 984	9049	4281	1130	1119
Other conifers	4	61	79	588	2124	7645	17 044
Other hardwood			4	3			
Poplar+W. birch	4331	14 579	45 829	84 002	57 115	15 557	8570
TOTAL	14 314	33 850	101 382	170 087	158 318	208 423	408 910

††Does not include site class IV and insufficiently restocked areas.

tion of skidding during the winter. Forwarding was split equally between forwarders and skidders. It is generally agreed that horse skidding on lowlands was less destructive than mechanical skidding and that winter skidding created less disturbance than summer skidding (Brumelis and Carleton 1988). This led to a harvesting method, Careful Logging Around Advance Regeneration (CLAAG), which emulates the minimal site damage of horse logging.

Full-tree harvesting

Full-tree harvesting operations began in 1980 and, by 1985, all harvesting done by SFPP was by this method. Although some full-tree harvested sites are represented in the data, none have yet produced merchantable volumes. There are some concerns about the long term ecological effects of full-tree harvesting (removal of nutrients) and the short term effects (removal of seed and increased surface disturbance).

Older plantations resemble natural stands

The old plantations represented in the data are very different from plantations being established today. Bonner (1952) stated that "we are planting entirely in cutover areas and make no attempt to obtain regularity of spacing. The policy is to plant on the roads, skidway sites and in the openings, generally to avoid planting near brush or established hardwoods". With this technique, Bonner felt they were duplicating natural stands by planting "clumps". By 1960, Spruce Falls was planting 1 to 1.5 million trees annually in this manner (Bonner 1960). Most of the seedlings were 2+2 transplants and planted as soon as possible following harvest to reduce competition problems.

Artificial regeneration follows 40% of harvesting operations

The planting program is now well established and SFPP has planted nearly 10 million seedlings annually over the past four years. According to SFPP, approximately 40 per cent of the total area harvested by the company is either planted or seeded. However, despite these increases in regeneration efforts, SFPP must manage with a certain amount of uncertainty in terms of volume prediction. A major objective of this study was to reduce this uncertainty.

1.3 Objectives

The major emphasis in this study was to address the needs of forest level planning. The following objectives were pursued:

1. To group the 14 operational groups of the FEC system into three or four classes of similar productivity for forest level forecasting and to evaluate the usefulness of the Forest Ecosystem Classification system for forest productivity studies.

tion system for forest productivity studies.

2. To construct density class volume curves and tables based on these productivity classes.
3. To construct volume curves based on the percentage of black spruce in the stands within each productivity class.
4. To develop individual-tree local volume tables for black spruce.
5. To develop a site treatment matrix to help identify gaps in the database in terms of operational groups and treatments.

Site specific objectives included:

1. Comparison of the growth and species composition of stands regenerating after harvest with that of undisturbed, old growth stands and to evaluate the effects of burning and plating as practised prior to 1970 on the species composition of post-cut stands.
2. Examining the response of black spruce stands to precommercial thinning and to determine the efficacy of thinning in increasing the black spruce volume in a stand and/or reducing rotation ages.
3. Examining the rate and cause of breakup of overmature black spruce stands.

2.0 STUDY AREA

The area is generally moist and flat

Most of SFPP's limits are in the Northern Clay Belt (Fig. 1), a region of clay soils laid down by Lake Ojibway during the retreat of the last ice age (Bonner 1952). The Clay Belt is characterized by Palaeozoic rocks covered by glacial marine Quarternary deposits with extensive, poorly drained flats, by occasional areas of hills and ridges, a few lakes, and dry-banked, sluggish streams and rivers. It is marked by little relief except when broken by river valleys (Jeglum 1974, Carleton and Maycock 1978). It has short but warm summers with abundant rainfall and winters with heavy snowfall (Brumelis and Carleton 1988); consequently, lack of water is not considered to be a growth limiting factor (Jeglum 1974) although excess moisture may affect growth.

Black spruce dominates the forest

The region covers an area of 52 378 km^2, of which 42 332 km^2 constitute productive forest land (Smith et al. 1987). Black spruce stands occupy 84% of the productive forest land. The rest is made up of white spruce (*Picea glauca* (Moench) Voss), balsam fir (*Abies balsamea* (L.) Mill.), jack pine (*Pinus banksiana* Lamb.), tamarack (*Larix laricina* (Du Roi) K. Koch), trembling aspen (*Populus tremuloides* Michx.), balsam poplar (*Populus balsamifera* L.), and white birch (*Betula papyrifera* Marsh). Cedar (*Thuja occidentalis* L.) occurs sparingly, usually as scrub growth in swamps.

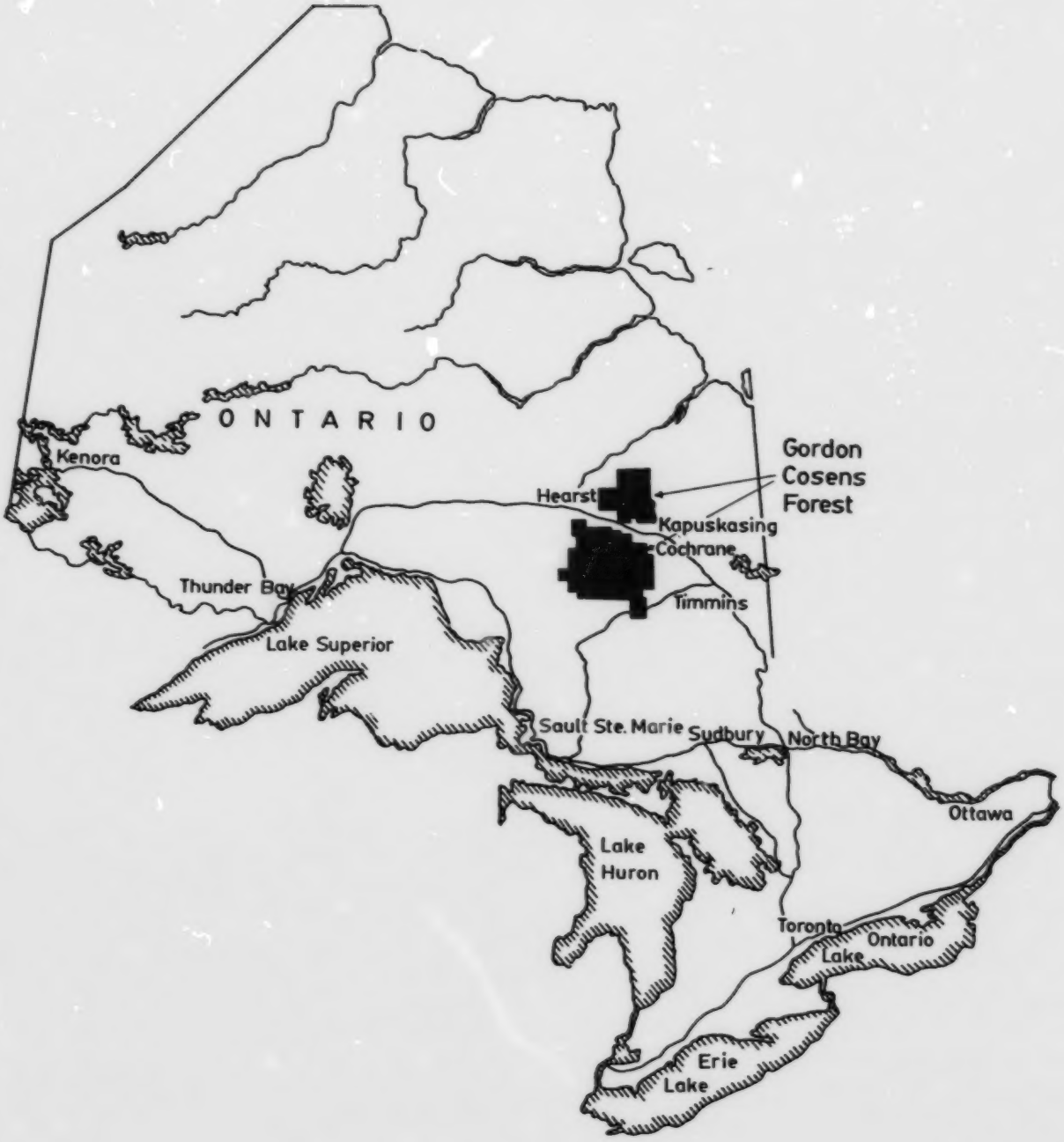


Figure 1. Location of the Gordon Cosens Forest within the Clay Belt Region of Northern Ontario.

3.0 SOURCES OF DATA

Data comes from PSP's

All data for this study were obtained from permanent sample plots remeasured at approximate 5-year intervals by SFPP. Until recently the standard plot size was 1 acre but plots established recently are either 1/2 or 1/4 acre in size. Stand age was determined at time of plot establishment as a rough average of the oldest dominant or codominant trees. In the case of second growth stands, stand age is the year of measurement minus the year of cutting (or, in the case of plantations, the year of planting).

Basic mensurational data were collected

Plots were established in even-aged stands with normal stocking (no openings) (Kirkpatrick 1982). Heights were measured on at least 10 dominant or codominant spruce over a range of dbh's, as well as for some other species. Some spruce heights may have been taken on intermediate trees in mixed stands where black spruce was not dominant[†]. While the average height of dominant or codominant trees in the plots was not recorded, the height-dbh data allow this to be estimated (Smith 1983). All silviculturally treated plots were paired with control plots of comparable age, site, and general condition. To date, of the 261 plots, 156 have been classified according to the FEC system operational groups (OG's) for the Clay Belt (see Table 4). Trees were not tagged and individual tree identity was not preserved.

4.0 METHODS

4.1 Height-Diameter Relationships

The Chapman-Richards function is used in this study

The Chapman-Richards function was chosen as a model for this study because it is very flexible, and the parameters of the model have at least a cursory physiological or biological interpretation (Ray, unpubl. ms., Pienaar and Turnbull 1973). It has also been applied successfully in other, similar, studies.

Height-dbh curves were estimated for all species

Black spruce height-diameter-age relationships were estimated by operational groups with an expanded version of the Chapman-Richards function. The general form of this equation is:

A separate curve was fitted for the thinned stands. For other species, data were only sufficient to produce one curve for each species to be used for all operational groups. In each case, the coefficients of the Chapman-Richards function were expanded to allow for linear changes over time (age) whenever age was found to be significant. These equations were used for the calculation of volume and top height. Top height was es-

Table 4. Number of permanent sample plots by mode of origin and subsequent treatment

Operational Group	Origin and Treatment							Total
	Natural			Cut			Other	
	Nil	Plant	Other	Nil	Plant	Other		
Not classified	31	0	6	34	21	8	5	105
1	0	0	0	0	0	0	0	0
2	1	1	0	0	0	0	1	3
3	5	0	0	0	0	0	0	5
4	0	0	0	0	0	0	0	0
5	2	0	0	0	0	0	0	2
6	1	1	0	0	1	0	0	3
7	45	3	5	1	14	0	8	76
8	5	0	0	0	0	0	0	5
9	11	1	1	2	1	0	0	16
10	2	0	1	2	1	0	0	6
11	10	0	0	2	0	0	0	12
12	7	0	1	1	1	0	0	10
13	11	0	0	2	0	0	1	14
14	3	0	0	1	0	0	0	4
TOTAL	134	6	14	45	39	8	15	261

[†]Baczynski, W., pers. comm.

timated from the largest 250 trees per hectare (Spurr 1952) which were identified via measured dbh and the estimated heights.

Curves are polymorphic

Height diameter curves should be polymorphic (i.e. curves for different sites should take different shapes) because the rate of height growth varies with dbh on different sites and generally culminates earlier on better sites (Smith 1983, Ray, unpubl. ms.). Each forest stand has its own height-age relation which depends on ecological conditions. Similarly, Hägglund (1981) stated that the function used to estimate height-age curves should be flexible enough to allow curves with different site indexes to take different forms.

4.2 Site Index Curves

Productivity classes are based on SI50

The Chapman-Richards function was fit to top height estimates to produce polymorphic site index curves for each operational group. These curves were then used to group the operational groups into three classes of similar productivity. Based on visual inspection, the curves were grouped into productivity classes. The comparisons were made primarily at 50 years, the site index age most widely used for black spruce (e.g., Payandeh 1978), although an index age of 100 has been used for black spruce in some studies (Smith and Watts 1987). This is prior to the possibility of extensive blowdown, which increases as tree height approaches 20 m (Woods and Beckwith 1987). Age-related changes in productivity class were evident within some operational groups. Therefore, ecosystem characteristics (see Jones et al. 1983) and opinions of local foresters were used to further refine the productivity groupings.

4.3 Black Spruce Local Volume Table Construction

Volume tables were produced for each productivity class

Local black spruce volume tables were produced for each productivity class based on new height-dbh-age relationships established for each productivity class. Heights were estimated by 2 cm dbh classes up to 40 cm; total and merchantable volumes were calculated based on Honer's volume tables (Kavanagh 1979). Tables are provided for 20-year age classes.

4.4 Calculation of Plot Volumes

Plot volumes were calculated as follows:

1. Black spruce heights were calculated for each diameter class in the stand table based on the height-diameter-age equations estimated earlier for each operational group. Heights were calculated by diameter class (but not OG) for the other species.
2. Total tree volumes were taken from Honer's Volume Tables (Kavanagh 1979).
3. Merchantable tree volumes were taken from Honer's tables based on a stump height of 20 cm and a minimum top diameter of 7.6 cm.
4. These tree volumes were multiplied by the number of stems in each diameter class to produce stock tables. Individual species volumes are the sum of the volumes by diameter class.
5. Net merchantable species volumes were calculated (for all ages and sites) using the following cull factors obtained from SFPP:

   black spruce - 2.5%
   balsam fir - 25%
   jack pine - 10.4%
   trembling aspen - 20%

6. Total stand volumes were obtained by summing individual species total volumes.

To facilitate volume curve estimation, residual trees left over from previous stands were excluded from stand volume calculations.

4.5 Density Class Volume Curves

Density classes were based on stand density at age 20

Plots were broken into three density classes (low: 0 to 3000, medium: 3000 to 6000, high: 6000+ stems/ha) based on the total number of stems per hectare at age 20. Age 20 represents a transition period with virtually no new recruitment and practically no self-thinning. This is consistent with other studies that show that black spruce establishment is active up to 20 years after fire (Arnup et al. 1988, Sirois and Payette 1989) and self-thinning of black spruce does not begin until 30 years or later (Carleton 1985, Carleton and Wannamaker 1987).

Density extrapolated for older stands

If the minimum age included in the data for a specific plot was greater than 20, density at 20 years of age was assessed by extrapolation of the average rate of self-thinning. If the plot minimum age was greater than 100 years, the plots were excluded from this analysis. Although there are several accepted ways to measure density, including basal area and Reineke's stand density index, the number of stems per hectare was chosen because it is simple and sufficient to meet the needs of this study.

Separate species net merchantable volume curves were drawn using a splining routine (SAS Institute 1989). The variable nature of these volume data as well as their scarcity led to very poor fits between the data and any standard curves tried. Thus, a cubic spline routine was used which smooths an interpolation line through the data.

4.6 Variable Species Composition Curves

Species composition classes based on percentage black spruce basal area

To determine if growing pure black spruce stands on sites capable of supporting mixed stands would result in a reduction of total volume, and to aid in wood supply projections, the plots were further classified based on the percentage of black spruce in the stand (black spruce: >75% black spruce by basal area at age of first measurement, and mixed: <75% black spruce by basal area at age of first measurement).

4.7 Second Growth, Thinning, and Mortality

The database is used to examine mortality and the effect of management

Species composition and total volume production of natural or "old growth" stands of fire origin were compared within operational groups with stands originating from harvest. Total volumes were compared because the stands had not reached commercial size. Merchantable black spruce volume, number of stems per hectare, and mean dbh of thinned black spruce plots were compared with equivalent data for control plots to evaluate the benefits of noncommercial thinning in black spruce stands. The decline of black spruce volume was compared to black spruce top height by plotting the black spruce merchantable volume of individual plots against top height. Comparisons were done by operational group.

5.0 RESULTS AND DISCUSSION

5.1 Productivity Classes

The results of classifying the OG's by site index

Based primarily on the black spruce site index at age 50, thirteen of the OG's (OG 14 was excluded because it was primarily unmerchantable stagnant growth) were grouped into three productivity classes as follows (also see Fig. 2):

Productivity class (site index) OG	Plonski (1960 site class)	OG (from Smith 1983)
	IA	3
I (> 12 m) 2,3,7,9	I	6,7
II (9-12 m) 5,6,8,10,13	II	4,5,9,10,13
III (7.5-9 m) 11,12	III	8,11,12

Two other classification schemes for black spruce are presented as well. Even though age-related changes in productivity class are apparent, regrouping the curves with 100 as the site index age would have only affected the classification of OG 8, which would have moved into class I. Curves for each productivity class are depicted in Fig. 2d.

OG's 6 and 10 are difficult to classify

Operational group 6 (lycopodium) was put into class II because its drainage ranges from good to imperfect, and it differs substantially from OG's 11 and 12 which occur on lowland peat soils with very poor drainage. Even though OG 10 is a productive upland site it fell into productivity class II. It is primarily a hardwood site (Jones et al. 1983), indicating that many of the black spruce used to estimate top height may have been in a suppressed or intermediate position in the stand. This illustrates the difficulty in obtaining a good estimate of site index from the lower stratum of mixed stands. However, at stand age 120, black spruce top height crosses that of OGs 7 and 8, which would put it into productivity class I. This could possibly be due to a release of suppressed black spruce as the hardwood component of the stand breaks up. Thus, these curves quantify actual average black spruce height growth rather than the potential growth.

Smith's classification scheme produces comparable results

Smith (1983) did some preliminary estimates of site indexes for most of the operational groups in order to relate them to Plonski's site classes. Because of good initial growth, he put OG 3 in a class by itself. Operational groups 6 and 7 formed class II which is consistent with our idea that OG 6 should be moved into class II. Although our rankings are fairly consistent with those obtained by Smith, the site indices he obtained were considerably lower. This may be a result of his use of stem analysis to estimate height growth. In contrast, our study used the dominant trees at the times of measurement to estimate height growth. If the trees change rank over time, particularly if the dominants are dying and are being replaced by former intermediate trees, these two methods of height growth estimation can produce considerably different results.

Site index has been used as an indicator of site quality

Ideally, site quality should be defined by recognizable site attributes or ecosystem characteristics (Pojar et al. 1987) such as indicator plants, drainage etc., but productivity does not always correlate well with these characteristics. A good site with respect to a particular species is one where establishment and growth of the species make relatively efficient use of environmental resources. Therefore, site index is commonly used as a surrogate measure of site quality and is the most widely accepted method (Hambly 1981). The main advantage of using site index is that it is relatively independent of stand density and distinctive to the species of interest. As well, it is independent of regionally developed ecosystem types. Heger and Lowry (1971) found Plonski's normal yield tables for black spruce applicable over a wide geographic range despite the large differences in the vegetation and moisture conditions encountered.

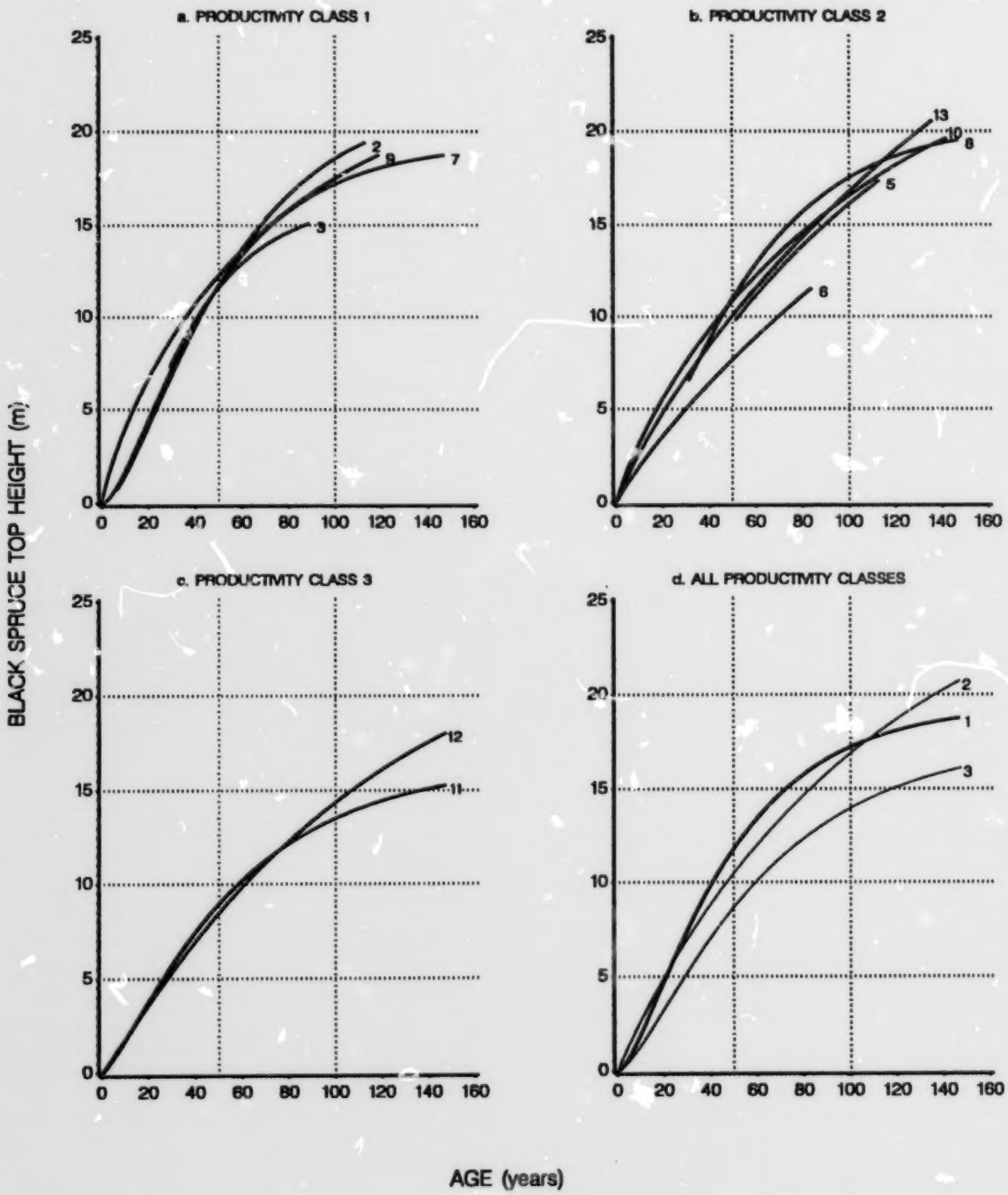


Figure 2. Black spruce site index curves for 12 operational groups. Productivity classes are based on the site index at age 50: a. Class 1 (>12 m), b. Class 2 (9-12 m), c. Class 3 (<9 m), and d. All classes.

Site index has limitations for use in forest management decision-making

The disadvantages of site index are that it cannot be determined without trees on the site, it can change with species, and it may not be valid in stands affected by insects or diseases. Nor is site index sufficient for making harvesting or silvicultural decisions. Because ecological conditions affect attainable productivity, it is operationally advantageous to integrate site index with an objective system of site classification. However, Heger and Lowry (1971) found normal yield tables were quite adequate for evaluating site and estimating black spruce volume in the Canadian boreal forest.

Ray used site index curve shape to classify OG's

Ray (unpubl. ms.) combined the OG's into seven categories by testing logical combinations of OG's based on ecological similarities. Large differences were noted in curve shape between OG categories of contrasting quality, but curves produced within one category had similar shapes. Thus, anamorphic site index curves could be developed for each operational group within a category. This may be realistic because there appears to be considerable variation in productivity within each category even though the curves may have similar shapes. A category, therefore, could represent a set of anamorphic curves, instead of representing a particular site index range.

Classifying by curve shape results in different groupings

By grouping curves of similar shape in this study, three classes were obtained which are substantially different from those derived by comparing the site index at age 50 (Fig. 3). The changes primarily involve shifts of OG's out of productivity class II. The curves could be classified as linear, slightly asymptotic, or strongly asymptotic. Although Ray (unpubl. ms.) noted that the fertile sites appeared to be more asymptotic than less fertile sites, the same generalization could not be made here. Smith (1984) found that black spruce continues to increase in height at a fairly constant rate throughout the life of the stand and that stands deteriorate and collapse before an asymptotic height is reached, but this was not confirmed in this study. Again, this may be an artifact of using remeasurement data rather than stem analysis. The groupings based on curve shape were not pursued further in this study.

Productivity classes are also different from SFPP's former classification scheme

Unfortunately, the classes based on SI at age 50 cannot be conveniently classified as upland, slopes, and lowlands, consistent with the inventory system formerly used by SFPP. This is not unexpected, because it is quite possible to have sites with the same growth potential (or site index) but different site attributes. Some lowland sites can be quite productive, especially if they have strong groundwater flow and well decomposed organic soil (e.g., OG 13) (Jones et al 1983).

This study's classification scheme is similar to New Brunswick's

Many ecosystem classification systems have been used as a basis for site quality estimation. The two most prominent in Canada are: (a) the biogeoclimatic system developed in British Columbia, which uses soil moisture and soil nutrient regimes to evaluate productivity (see Pojar et al. 1987); and (b) the site classification system developed by Zelazny et al. (1989) for New Brunswick. In New Brunswick, site types are grouped on the basis of productivity as determined by site index at age 50, similar to the approach in this study.

5.2 Forest Level Predictions

5.2.1 Density class curves

Density classes are required to account for open stand conditions

The effect of density on volume growth is of particular concern to SFPP because Spruce Falls' foresters feel the PSP's are not representative of some of the open stand conditions found within their limits, and subsequently overestimate volume production. This can lead to serious wood supply problems. Therefore, plots were separated into three density classes. As expected, few plots had been established in low density conditions; consistent with the SFPP Permanent Sample Plot Manual which states that plots are to be established in fairly dense stands (normal stocking with no openings - see Kirkpatrick 1982).

Density classes reveal differences in volume production

Variability in volume production was very high within each density and productivity class (Fig. 4). There was no consistent trend between "HIGH" and "MEDIUM" densities for any productivity class. This is probably because the density classes are very broad, few plots were representative of a low density, and many of the trees tallied were probably shorter than breast height (Kirkpatrick 1982). These small trees were probably regeneration and thus would not have affected the growth of larger merchantable trees.

5.2.2 Volume production

Black spruce volume peaks between ages 75 and 95 for productivity class I

Net merchantable volume curves for the species currently of commercial interest (Fig. 5) provide more revealing and useful information, particularly for annual allowable harvest estimates. Black spruce produces the most volume in class I but volume begins to decline around age 100 in very dense stands and at age 75 in stands of medium density. This is consistent with the findings of Smith (1983) who found black spruce volume fell off be-

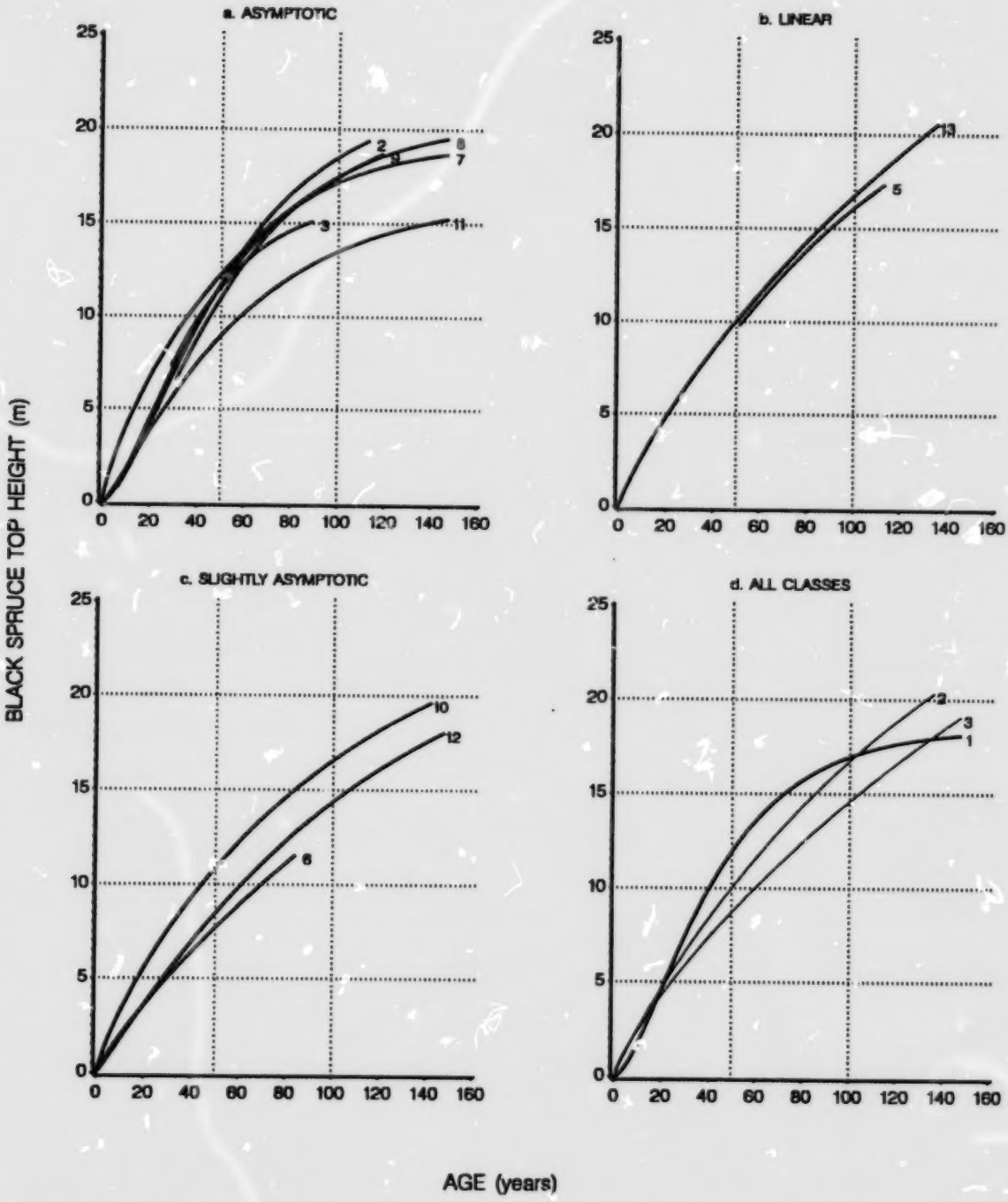


Figure 3. Black spruce site index curves for 12 operational groups. Shape classes are based on the shape of the curve: 1. Asymptotic, 2. Linear, 3. Slightly asymptotic, and 4. All shapes.

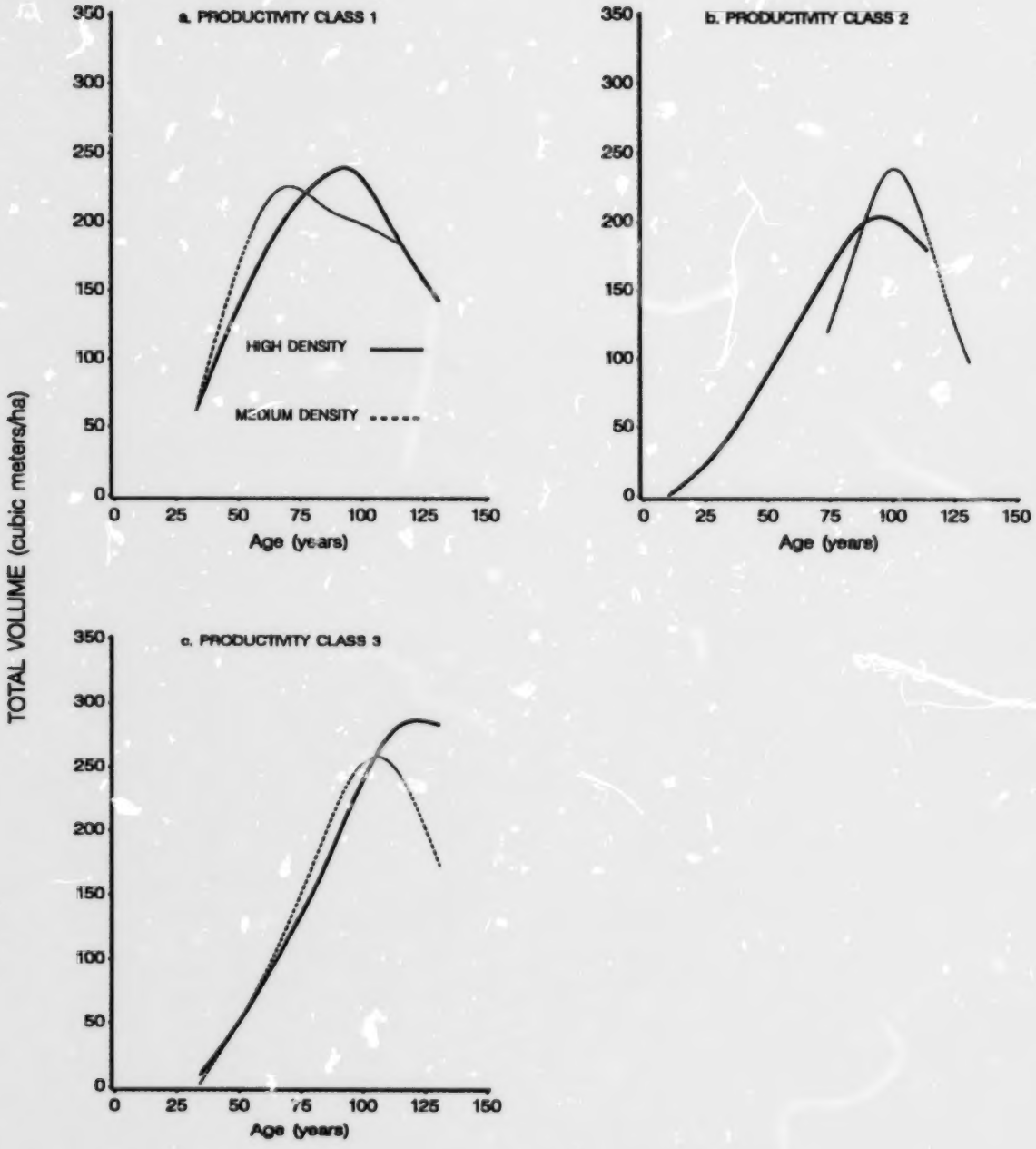


Figure 4. Total volume over age curves for three productivity classes for all species combined and two density classes.

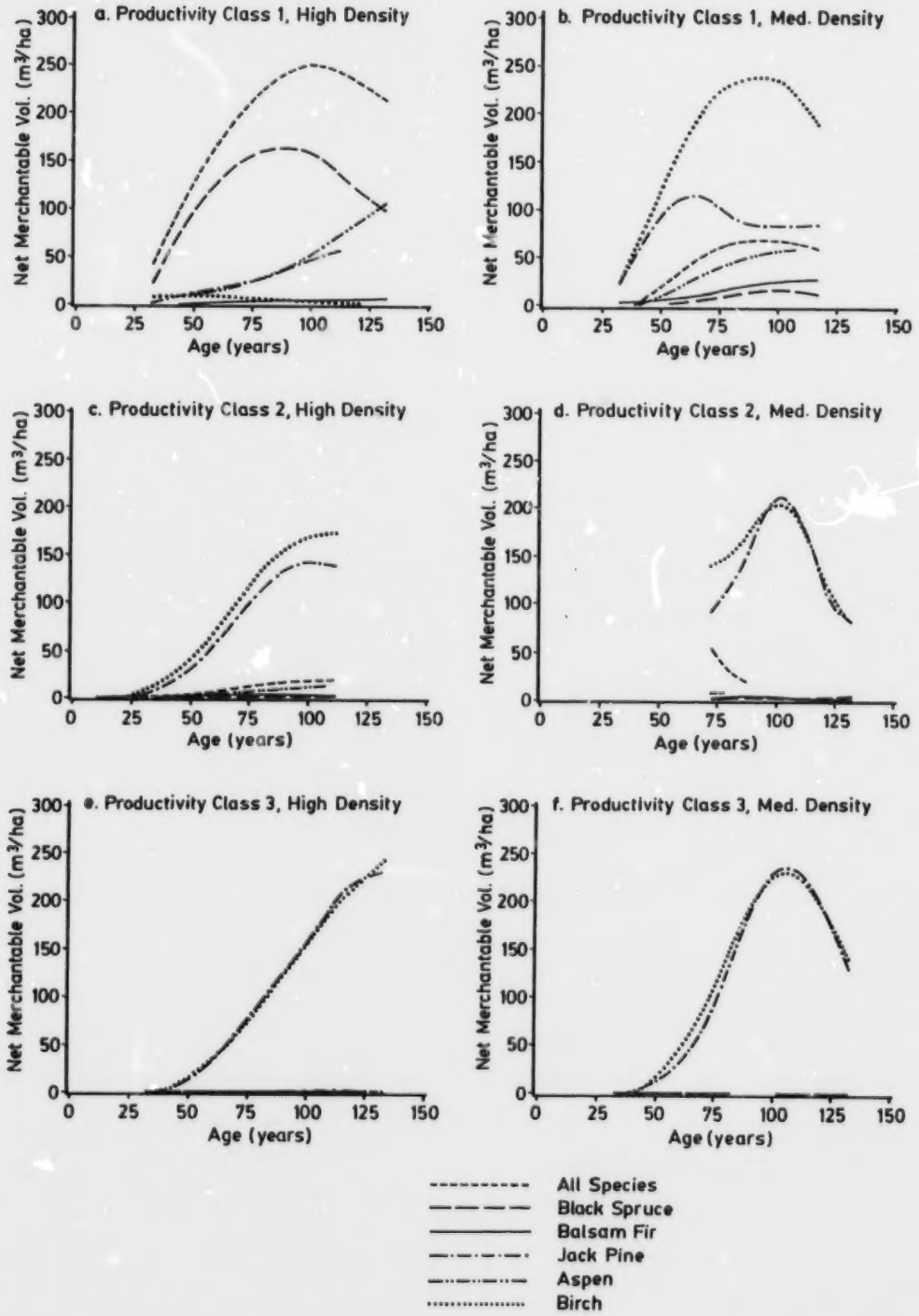


Figure 5. Merchantable volume curves for three productivity classes and two density classes for five commercial species.

tween ages 75 and 100 on good sites. When black spruce volume declines there is an increase in both trembling aspen and jack pine volume. This is not due to an increase in the number of stems for either of these species but, instead, to an increased mean dbh or a decreased number of stems per cubic meter (see appendix for merchantable volume tables). This indicates that aspen and jack pine may be outliving black spruce on these sites, in contrast to findings of Carleton and Maycock (1978). They state that as upland stands age, black spruce trees increase in size and outlive jack pine. Black spruce volume peaked at approximately 160 m^3/ha (at age 95) but falls below 100 m^3/ha at 120 years, similar to that indicated by SFPP harvest data which estimated that 98 m^3/ha of black spruce was being salvaged from overmature upland sites (Williams 1987).

Black spruce volume peaks at age 100 for productivity class II

Black spruce volume dominates productivity class II and volume begins to decline after 100 years, slightly later than in productivity class I. Smith (1983) found that significant mortality set in after 120 years. Again, aspen volume increases with the decline of black spruce, but not to the extent of class I. Most of the aspen volume occurred in OG 10, a hardwood-aspen site (Jones et al. 1983).

Black spruce volume peaks at age 120 for productivity class III

Black spruce is the only species producing significant volume in class III, which is comprised only of OG's 11 and 12 - two very poorly drained organic soil sites. Volume drops off after 120 years. Black spruce volume peaks at 220 m^3/h a but falls below 150 m^3/ha after 125 years, which is slightly lower than the 158 m^3/ha indicated by SFPP harvest figures from lowland sites (Williams 1987). Thus, the lowland sites generally produce relatively more black spruce volume than upland sites.

Substantial volume loss occurs soon after volume peaks

Our study is in agreement with most other studies which indicate that overmature stands tend to remain open until rejuvenated by fire or some other mechanism (Carleton and Maycock 1978). It also confirms that once stand breakup begins, it generally proceeds quite rapidly, with some stands losing up to half their volume in 10 years (Arnup et al. 1988).

Volume tends to converge over time regardless of initial density

Similar volume peaks between high density and medium density stands indicate that understocked stands grow faster than fully stocked stands and that overstocked stands tend to grow more slowly than fully stocked stands (Evert 1970); thus, there is a convergence of volume over time. Bell et al. (1990) indicated that stands with a high initial density should increase rapidly in volume with peak growth (i.e., the steepest part of the curve) occurring early, while low density stands grow slowly at first.

5.2.3 Effect of species composition on volume production

Total volume and basal area are similar for mixed and pure stands for class I

Separation of the productivity classes into "black spruce" type (greater than 75% black spruce by basal area) and "mixed" type (less than 75% black spruce by basal area) revealed little difference in total volume production between "mixed" and pure "black spruce" stands (Fig. 6). This differs from the findings of Jameson (1953) in the Clay Belt and Van Cleve et al. (1983) in Alaska who found that mixed stands of 120 to 150 years of age produced much more volume than black spruce stands of similar ages. For class I, black spruce stands produce slightly more volume, although the annual increment rates are similar. As expected, the "pure" black spruce stands reach peak volume slightly later, but decline at a rate comparable to that of mixed stands once the stands begin to break up. The basal area for the mixed stands is slightly higher (see Appendix).

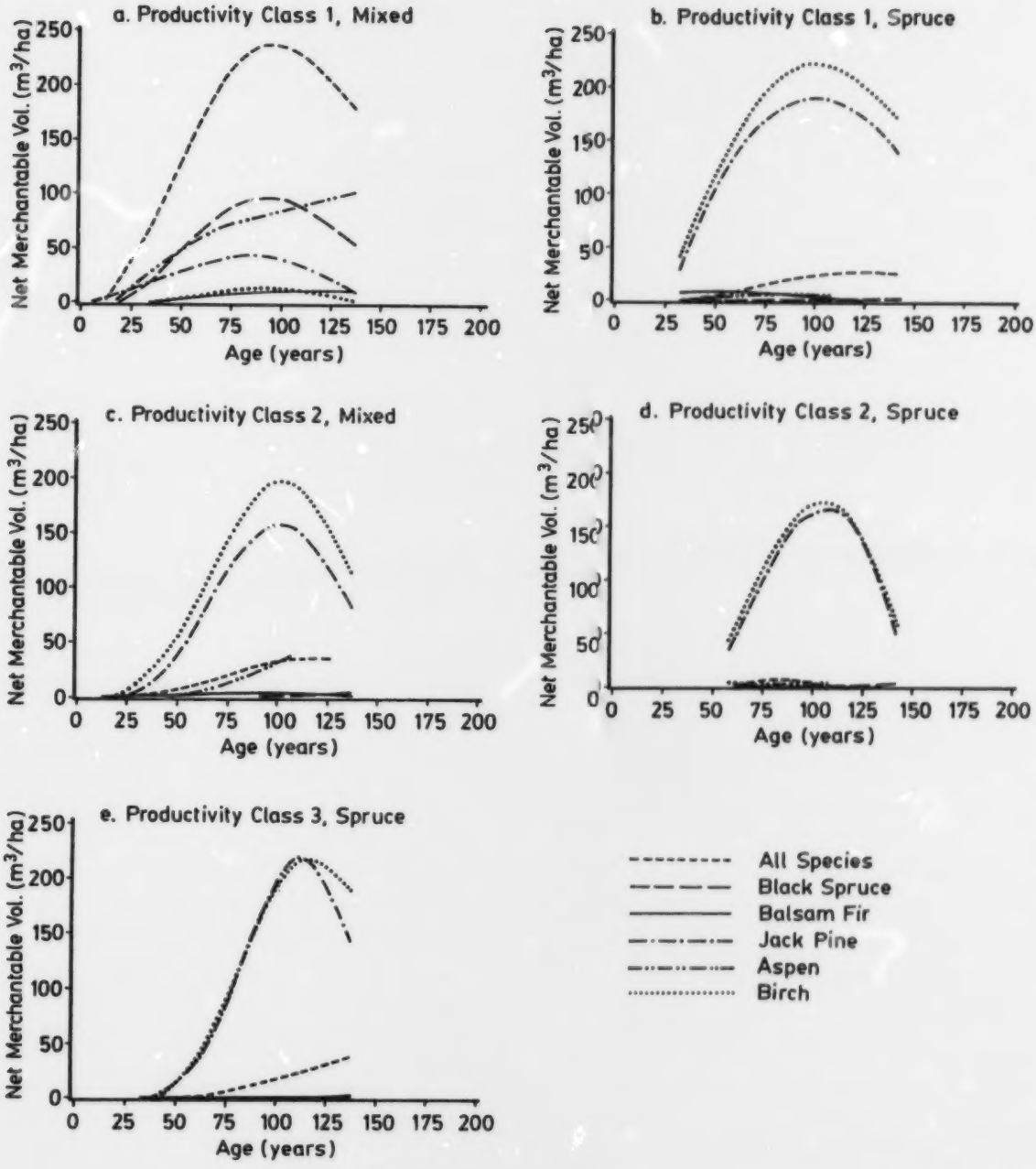
Total volume of pure stands is less than for mixed stands for class II

In contrast, in productivity class II the total volume in mixed stands was significantly higher than in "black spruce" stands. This is probably partly due to the influence of OG 10 in this class. Therefore, if black spruce is planted in the hardwood-aspen site there will be a decrease in total volume production. In terms of net merchantable volume, aspen and spruce produced approximately equal volumes in the "mixed" stands of productivity class I while black spruce dominated all the other sites.

5.2.4 Individual tree black spruce local volume tables

Volume tables are given in the appendix

Total and merchantable volumes for black spruce are given for each productivity class in the Appendix. The tables are broken into 20-year age classes and 2 cm dbh classes. Merchantable volumes have been calculated based on a stump height of 20 cm and a top diameter of 7.6 cm. There are significant differences in volume between the productivity classes for a particular age and dbh, indicating that site quality affects tree form. It should be noted that these tables are specific to the operational group stratification described earlier. Additional site data may lead to new strata and require construction of new tables.



ls with greater or less than 75 per cent black spruce by

Figure 6. Merchantable volume curves for three productivity classes for standmercial species.
basal area. Curves are given for five com

5.3 Site Specific Findings

5.3.1 Fire-origin versus post-harvest stands

Burning and planting at site prior to 1960 have no noticeable effect on species composition and volume

Visual comparison of prescribed burned versus unburned and planted versus untreated cutovers in terms of both species composition and volume revealed little noticeable difference in post-harvest stand performance (Table 5). This confirms Vincent's (1961) belief that although fires are beneficial in improving seedbeds and removing competing vegetation, in cutover stands they may be detrimental unless a seed source is near at hand. It also confirmed the suspicions of local foresters that the "old" plantations would perform no differently than natural stands. Similarly, in a study of older plantations within SFPP's limits, Willcocks (1979) found that only one of eight spruce plantations contained enough spruce to be classed into the Spruce working group, even though the intent of early plantations was to increase the content of black spruce in cutovers (Bonner 1952).

Post-harvest stands are compared with natural stands of OG's 7, 9, and 13

Therefore, cut and cut-and-burned and natural and planted cutovers were combined for further analysis. Total volumes of black spruce, other conifers, and deciduous species were used to compare the development of the cutovers with that of old growth stands. Operational groups were used as a basis for comparison, but data availability limited the comparison to OG's 7, 9, and 13.

Occurrence of black spruce and total volume lower in post-harvest stands

In post-harvest stands black spruce volume growth was considerably lower following cutting, compared to fire-origin stands (Fig. 7). As well, the volume growth of other conifers (mostly balsam fir) increased dramatically after cutting. However, only in OG 7 (mixedwood-herb rich) did the post-harvest volume of deciduous species exceed that of fire-origin stands. Similarly, Harvey and Bergeron (1989) and Brumelis and Carleton (1988) indicated that mixed species sites generally have a greater component of hardwood following harvest. This is probably due to soil disturbance caused by mechanical skidding, producing a substrate with a higher nutrient turnover rate that places faster growing hardwoods at a competitive advantage over black spruce (Brumelis and Carleton 1988).

Only OG 7 shows higher deciduous volume

The fact that the volume of hardwoods only increased in the mixed OG is not surprising because the other two OG's are conifer-herb/moss rich (OG 9) and aspen-herb rich (OG 13) ecosystems primarily dominated by conifers. A consequence could be a shortage of suitable seed or seed beds for deciduous species on these latter sites.

Other studies do not agree on whether black spruce content is less or the same following harvest

Brumelis and Carleton (1988) indicated that black spruce stands of fire origin were being replaced by species of lower commercial value. They found trembling aspen mainly in stands less than 30 years old, which corresponded to the change from horse to wheeled skidding. Similarly, Virgo (no date) indicated that wheeled skidders badly damaged advance growth and encouraged heavy sedge, alder, and grass cover. The increase of balsam fir and decrease of black spruce following harvest has been well documented in other studies (Yang and Fry 1981, Arnup et al. 1988). Balsam fir is poorly adapted to survival after fire (Larsen 1980), making it less plentiful in young fire-origin stands. In contrast, Vezina and Falardeau (1988) stated that species composition and merchantable volume were similar in post-fire and post-harvest stands in northern Québec, but that trees were smaller and more abundant following harvest.

Table 5. The relationship between productivity class and maximum mean annual increment (MAI) and range for each mode of origin. Stand age corresponding to the MAI is given in brackets. Only those stands in which MAI peaked are included in the summary

Productivity Class	Mode of Origin	Treatment	MAI (age) - m^3/ha (years)		
			average	max	min
1	natural	none	2.80(88)	4.93(57)	1.28(30)
1	cut	none	3.65(33)	8.27(15)	0.98(36)
2	natural	none	1.89(89)	2.63(98)	0.91(71)
2	cut	none	2.22(24)	4.88(37)	0.67(25)
3	natural	none	1.75(128)	2.97(115)	0.93(74)

5.3.2 Effects of noncommercial thinning on growth and yield

40 years after thinning, thinned plots resemble the control plots

Two black spruce plots thinned at ages 37 and 44 were compared to control plots that received no treatment.

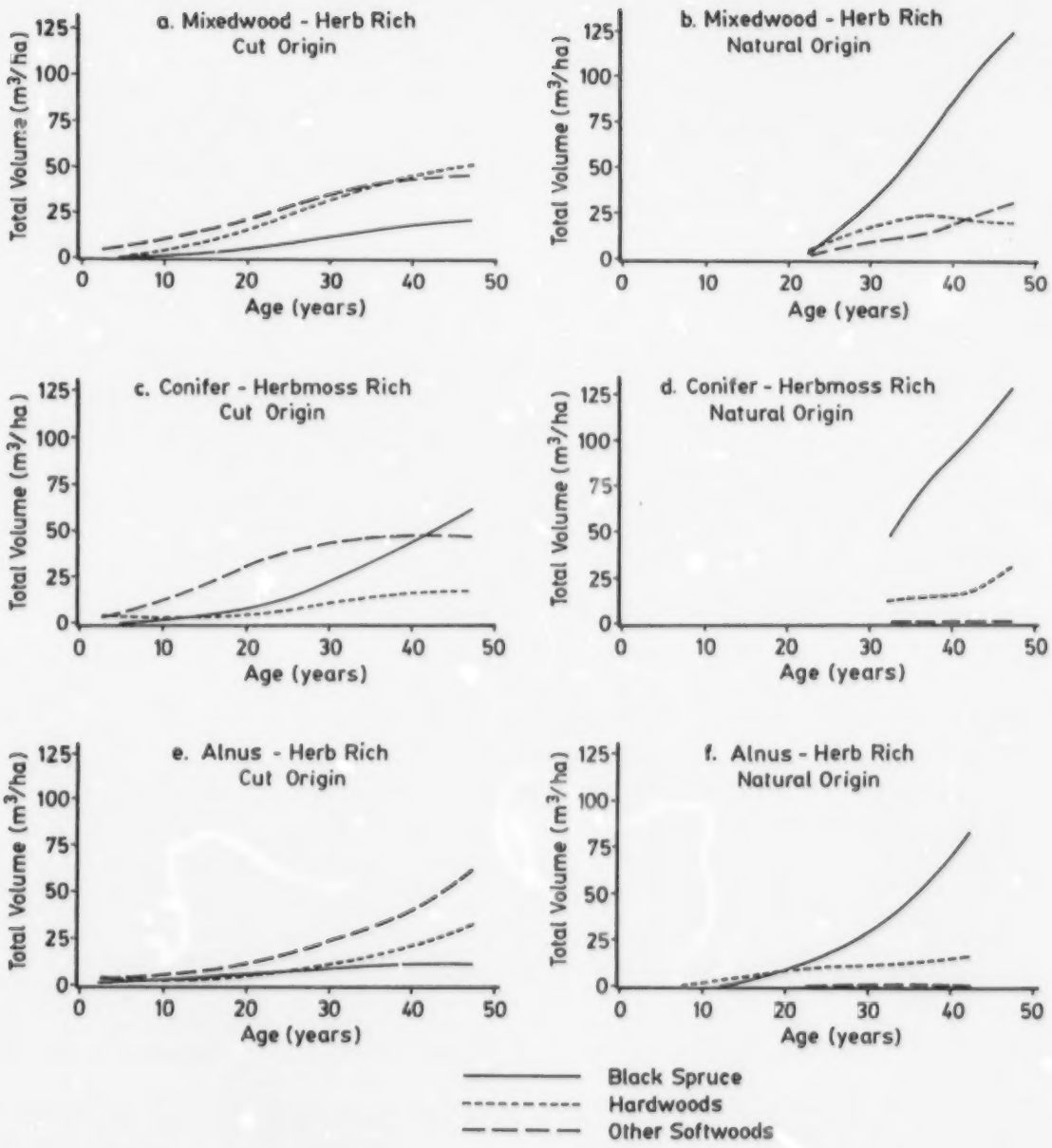


Figure 7. A comparison of total volume for black spruce, other softwood, and hardwood for three operational groups between cut-origin and fire-origin stands: A - B. Mixedwood - herb rich (OG 7), C - D. Conifer - herb/moss rich (OF 9), and E - F. *Alnus* - herb rich (OG 13).

Approximately 40 years after thinning, the untreated stands are remarkably similar to the thinned stands in merchantable volumes and the number of stems per hectare (Fig. 8). Five to 10 years ago the unthinned stands both had higher merchantable volumes that the respective thinned stands, indicating that thinning would have reduced the volume available for harvest at that time. Volume is declining in the control stands, but is still increasing in the thinned stands. It appears as though thinning may have lengthened the optimum rotation age, inconsistent with the usual reasons for precommercial thinning, i.e., shortening rotation ages by increasing piece size. However, SFPP has an age class imbalance, with much area classified as overmature. Thinning may be one technique for delaying significant volume loss due to breakup.

Thinning was too late

At first glance, thinning does not appear to produce any benefits, but this is probably a function of stand condition and species composition at the time of thinning. Both plots were well advanced into the pole stage and self-thinning had already begun. If the stands had been thinned earlier, the leafed trees would probably have been more vigorous and thus would have responded to the increased growing space more quickly. Also, because the thinned plots were almost pure black spruce prior to thinning there was little opportunity to alter species composition, often a major benefit from precommercial thinning.

5.3.3 A possible cause of stand breakup

Shallow rooting and limited mechanical support cause blowdown

Black spruce is shallow rooted, and it has been hypothesized that the timing of stand break-up in the Clay Belt is dependent upon the height of trees (Smith et al. 1987, Woods and Beckwith 1987). Once black spruce trees surpass a critical height, they become susceptible to blowdown (Smith 1983). He found that black spruce stands on better sites began to collapse when dominant stand height reached 20-21 m. This was partly attributed to poorly drained organic and gleysol soils which had little mechanical strength and allowed limited rooting depth (Smith et al. 1987).

A graph of black spruce volume versus top height (Fig. 9) supports this hypothesis. In fact, top height even decreased in some cases when volume declined. Some of the variation in top height at the time of volume decline could be due to variations in density; dense stands are better able to dissipate incoming winds and are more stable due to interlocking root systems (Smith et al. 1987).

5.4 PSP Program Evaluation and Gaps in Database

The need for program evaluation

The SFPP permanent sample plot data represent the most extensive measurements on black spruce in the Ontario Clay Belt. Because measurements date back to the 1930s, a time when forest management practises were quite different from those today, it is important that the PSP program be evaluated periodically. Are the data collected still providing useful information? Is this the most effective way of obtaining such data? Should the program be expanded or changed in other ways?

Objectives of a PSP program

In general, permanent sample plots (PSP's) are set up to monitor stand dynamics and to provide data for predicting response to changes in treatment or environment (Curtis 1983). This implies that the PSP's should be representative of a larger area of interest or include management interventions that are of interest to the company (e.g., thinning, drainage) and be long term in nature. The PSP data were used in this case to construct local volume tables, a fairly common use of such data. The PSP's will be evaluated in terms of providing data for growth and yield modelling.

PSP's can be described in terms of the forest stand and management conditions they represent and the subset of this information that is actually measured and recorded. These attributes will hereafter be referred to as 'location' and 'measurements'.

Location

The location of a PSP refers to the forest site, stand, and management condition the plot is intended to represent. The Ontario Clay Belt has a wide range of site conditions resulting in considerable variation in the growth of black spruce. To increase the precision of growth and yield estimates, the area should be stratified into stands with similar growth patterns. In terms of growth and yield, stands grouped into a stratum should be more similar to one another than to stands in another stratum. However, other factors besides growth affect forest management (e.g., terrain and slope will affect harvest and site preparation) and may also affect the stratification criteria. At the present time, the Forest Ecosystem Classification (FEC) system is being tried in the Clay Belt. This system was designed to aid in operational planning, not growth and yield forecasting. Although the system may not be the best stratification system for growth and yield, it's availability and usefulness for making other decisions may make it a good choice for management purposes.

Overrepresentation of OG 7

As can be seen in the Table 4 there are no plots classified as OG 1 or 4, but data are plentiful for OG 7. It is difficult to determine how many plots should represent

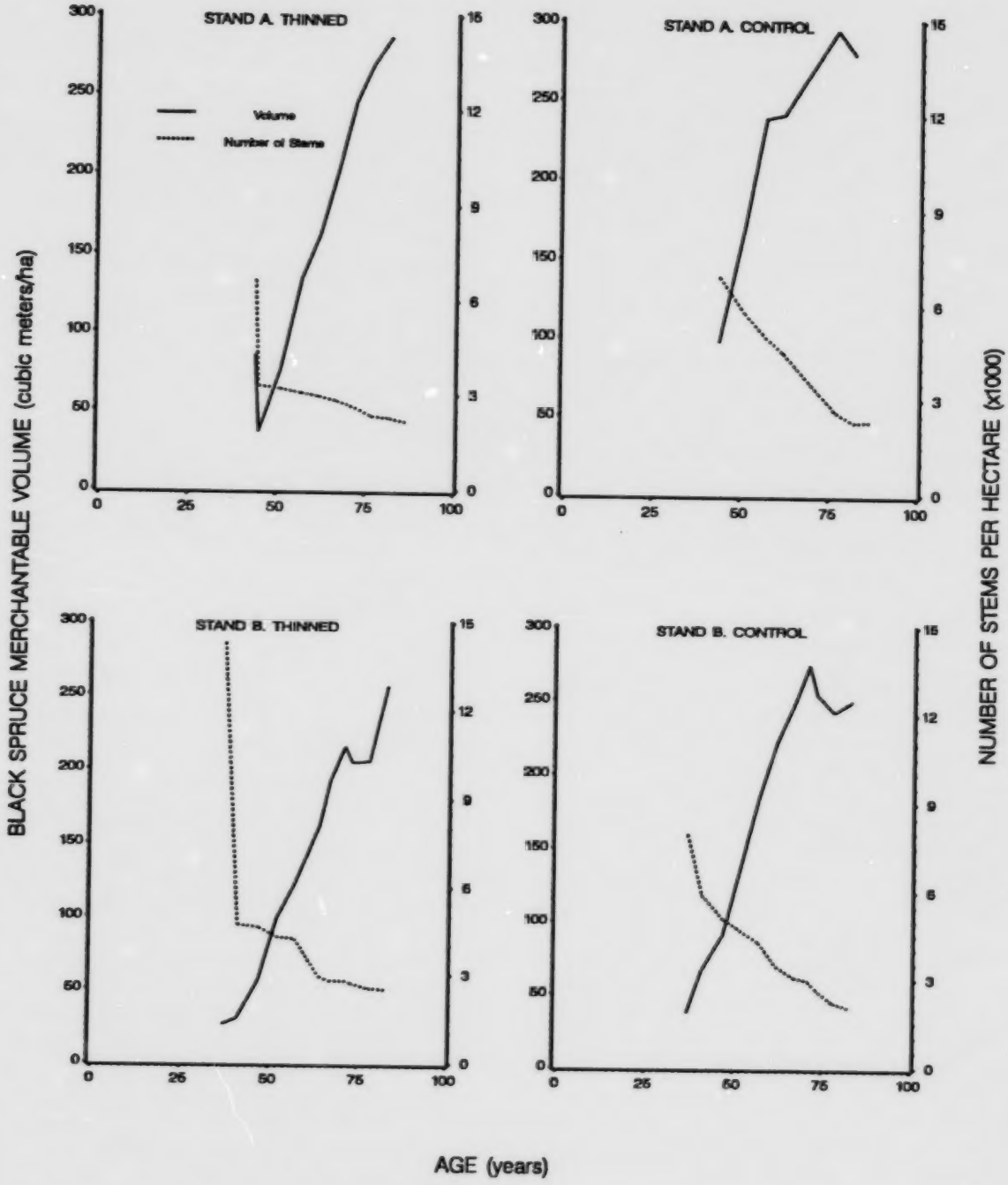


Figure 8. A comparison of thinned and control plots in terms of black spruce merchantable volume and number of stems per hectare from time of thinning.

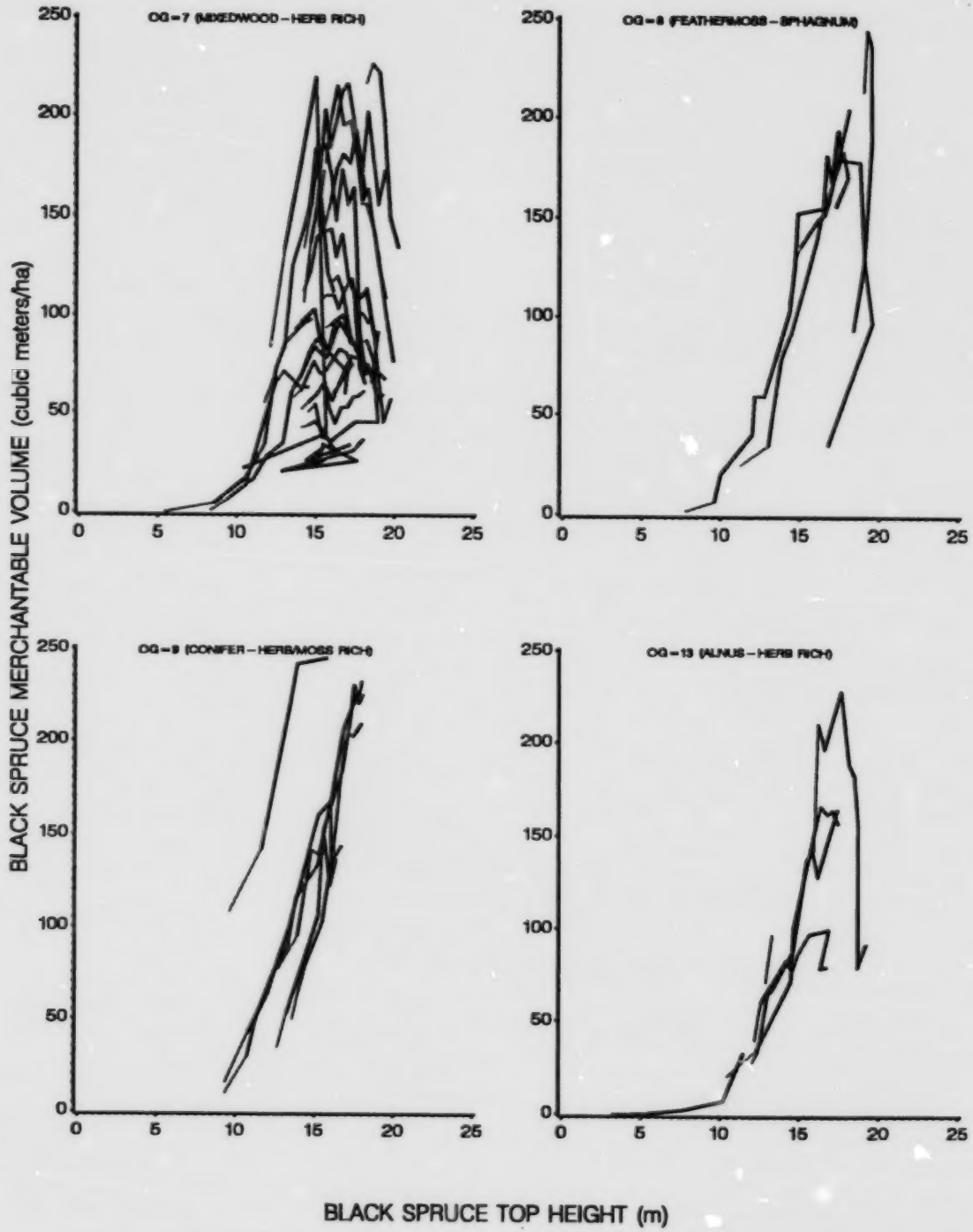


Figure 9. Black spruce merchantable volume versus black spruce top height for four operational groups.

each OG, but they should probably be proportional to the importance of each OG to SFPP. If OG 14 represents noncommercial stands, fewer plots should be allocated to that particular OG. If the majority of the wood comes from OG 7, then it should have the majority of the plots. This is important because the volume curves produced in this report are heavily weighted toward the OG's with the most data.

Insufficient representation of treatments

Generally, there should be more plots established in silvicultural treatments such as thinning, fertilization, herbicide spraying, and drainage that may become more important in the future, should management intensify. Plots should also be established in more open conditions or less dense stands as well as in stands regenerating after current harvesting (full tree) techniques. However, any plots established in conditions not representative of the forest should be carefully considered, because PSP's should represent the forest of interest. Once the management area is stratified into FEC OG's, those groups with potential for management (including harvesting, regeneration, and any other silvicultural treatment) should be identified and represented by PSP's. Some groups may be eliminated because of low productivity and because of economic inaccessibility.

Measurements

Plot measurements include the physical layout of the plot as well as the attributes measured.

Plot layout

Chappel et al. (1988) provide some guidelines on PSP size. The plots should be large enough so that

(a) the number of trees is sufficient to obtain reasonable estimates of the diameter distribution,
(b) the number of trees allows a reasonable level of thinning,
(c) death of individual trees or small groups will not greatly affect plot values, and
(d) plot values reflect those of operationally treated areas.

These requirements may be summed up by saying the PSP values should reflect stand values. However, the larger the plot, the more time and money is expended obtaining measurements and fewer plots can be maintained for a given cost.

A buffer (usually the width corresponds to the average height of a mature, dominant tree) should be maintained around each plot. The buffer should be similar to the PSP in terms of stand attributes. The purpose of the buffer is to maintain the homogeneity of the PSP, i.e., each tree in the PSP should have approximately the same growing conditions regardless of whether it's in the plot centre or near the boundary. A double buffer along one side may prove to be valuable if destructive sampling is anticipated.

Attributes measured

Although forests are usually managed as 'stands', it is the individual tree attributes which determine the final product. Therefore, just as repeated measures on the same plot are required for predicting stand growth, repeated measures on individual trees are required for predicting individual tree growth. Thus, individual trees should be tagged so that the data may be used to predict individual tree growth or mortality. Individual tree growth rates are important for investigating competition effects and mortality. Minimal measurements include dbh of all plot trees above a certain dbh (usually 4 cm).

Inclusion of more detailed studies

The SFPP PSP's are designed to monitor stand dynamics. This provides valuable information on growth under current conditions. However, prediction of growth under changing conditions (management and environmental) requires studies which investigate the underlying processes affecting growth including nutrient cycling, biomass accumulation and partitioning, and seedling establishment requirements. Such studies require more detailed planning and require more detailed and frequent measurements over a fewer number of years than the PSP system. These studies should be compatible with the PSP system (i.e., measuring and classification systems should be the same). Such process studies should begin to answer questions such as 'Why does productivity differ between old and second growth?' and 'What factors (nutrients) are limiting growth?'. This information may then be used to evaluate the effectiveness of silvicultural efforts in achieving the desired objectives.

Recommendation 1: SFPP expand its current PSP system to better represent all the OG's within its limits.
Recommendation 2: The current and potential harvesting techniques, plantations, and other potential silvicultural treatments such as control of competing vegetation and spacing be reflected in the PSP's.
Recommendation 3: SFPP superimpose a smaller plot on the current plots, tag the trees on the smaller plot, and follow the guidelines of Curtis (1983) concerning remeasurement. The larger plot should be maintained and measured in the historical manner and will serve as an important buffer around the smaller, more intensely measured plot.
Recommendation 4: Establish plots to study ingrowth. These may be subplots of the larger PSP's measured for the first 30 years.
Recommendation 5: Studies be initiated to investigate nutrient cycling, the relationship between water table and tree growth, and regeneration establishment requirements.

5.5 Study Limitations

The results reported here must be kept within the context of the study if they are not to be misleading. The limitations of this study can be grouped into three main categories: 1. Data Limitations, 2. Changes in Harvesting Practices, and 3. Operational Requirements.

1. *Data Limitations*

There is a wealth of information in the database which SFPP has maintained since the 1930s, and SFPP personnel are to be commended in this regard. However, because individual tree records were not kept from one remeasurement to the next, individual trees could not be tracked through time. As a result, the only age available is plot age, determined at the time of establishment (usually from date of disturbance). This is not a serious problem for intolerant pioneer species which often form true even-aged stands, but it is a problem for black spruce which may become established over a considerable period of time following fire (see Sirois and Payette 1989). As well, as stands break up, the canopy trees tend to become uneven-aged. Therefore, some of the variation between plots within an OG may be the result of age variation within plots due to prolonged post-disturbance recruitment.

As mentioned previously, the proportion of plots representing each operational group in the productivity classes may not be representative of the actual proportion of OG's found in the Gordon Cosens Forest. As the entire area has not yet been classified, this cannot be checked. But the yield curves may be biased towards any overrepresented OG's. Another limitation is the lack of plots in open conditions, leading to data that are inadequate to predict yields in less dense stands.

When plots are joined in a chronological sequence there is usually a dramatic increase in variability of the data due to differences in species composition, etc. despite being classified similarly. This is a problem inherent in most ecological studies where one plot does not represent the range of ages of interest, and it is an almost universal deficiency in forest PSP databases. It should be noted that the SFPP PSP system contains the longest measurement records on black spruce growth in the Clay Belt, and some of the longest sequences in the province.

The final limitation of the data is that black and white spruce have not been separated in the stand table tallies. If a high percentage of the spruce is black spruce as is indicated by local foresters, this is probably not a problem, but it could pose problems for future modelling.

2. *Changes in Harvest Practice*

Some of the post-harvest stands used in this study are not representative of stand development following the full-tree harvesting commonplace today. Thus, some of the comparisons made are not valid for current harvesting techniques. This is particularly true for those plots harvested from the mid-1960s to the mid-70s when there was considerably more site disturbance than there is with today's high flotation tires. The effect of current harvesting practises is comparable to that of horse logging. However, the study does give an idea of how the stands established during this period are performing compared to fire-origin stands.

3. *Operational Needs*

Curves for average forest conditions are needed for forest level projections. This made it necessary to use techniques that were a compromise between the best methods available and the variability of the data. The productivity classes established in this report are very broad and are not adequate for predicting individual stand yields. Thus, the curves will probably not be correct for any individual stand, but should be correct on average for the conditions they represent. Operational groups (within the FEC system) were not developed with productivity in mind and other classifications or a finer breakdown (i.e. vegetation types) would likely produce much less variable results.

Because this preliminary and exploratory report has been written primarily for an operational audience, these trade-offs and assumptions were considered necessary and acceptable. A parallel is Plonski's yield tables which were also designed to serve requirements for forest planning on a broad scale (Arnup et al. 1988).

As Baskerville (1982) indicated, forecasting problems centre on scale and direction. Science, unfortunately, commonly addresses dynamics at a scale not usable in management decision-making. Further, Baskerville (1986) stated that it is not just more yield data that is needed, but specific information in a particular form that permits a more rational link between area and volume in forest management. He stated that if the process becomes separated from the user it may become an exercise in administration of yield data, rather than the creation of better yield information.

6.0 CONCLUSIONS AND RECOMMENDATIONS

Although site indices (productivity) of the individual operational groups in the Forest Ecosystem Classification system are quite variable, they can be grouped on the basis of productivity if the resultant increase in variability is acceptable. Thus, the FEC system can probably be expanded to include a concept of productivity in the future; this needs to be studied in more detail.

Separate species volume curves developed for two of the three productivity classes varied considerably, largely due to differences in species composition between plots within the classes. However, the black spruce com-

ponent and total stand volume peak earlier in class I and also declines at an earlier age, indicating that these stands should be harvested before age 100 to avoid considerable volume loss. However, it appears as though trembling aspen and jack pine are longer-lived than black spruce on these sites.

These data support the hypothesis that black spruce volume decline is linked to black spruce dominant height, although at a slightly lower height than Smith's (1983) 20-21 m. Most stands experience significant mortality at a similar top height (17-20 m), which is reached at an earlier age on the better sites. This has important implications for harvest scheduling.

Total volume production in mixed stands was, as a rule, slightly greater than in pure black spruce stands, indicating that managing for black spruce on some sites would likely result in a small loss in total volume, but would definitely result in an increase in commercial volume if market conditions remain relatively constant.

Separate yield curves should be developed for post-harvest and old growth stands. Post-harvest stands generally produce significantly less black spruce volume and considerably more balsam fir volume, and on mixed sites (OC 7) harvesting also produced a higher proportion of deciduous volume. It is possible that non-commercial thinning could be used to improve species composition in post-harvest stands to concentrate growth on a more valuable species such as black spruce. However, because stands thinned in this study were primarily of fire origin, with a high black spruce content thinned at a late age, thinning did not produce measurable benefits.

This study was exploratory in nature, so some recommendations for further study are warranted:

1. Develop less variable productivity classes based on the 23 vegetation types or other classifier variables used within the FEC system which can be input into a model.
2. Examine the usefulness of the FEC system as a basis for stand management decisions such as silvicultural prescriptions, growth and yield forecasting, and other forest uses.
3. Investigate the timing and rate of stand breakup, perhaps leading to a "risk model" for use in prioritizing areas for harvest.
4. Collect more detailed information from existing permanent sample plots, including data on individual tree ages and ecosystem characteristics.
5. Establish new plots to fill gaps in the database.

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APPENDIX 1. **Black spruce individual tree local volume tables for the Ontario Clay Belt. Volumes are given in cubic metres by 20-year age class and 2cm dbh class. Merchantable volumes are based on a top inside diameter of 7.5cm and a stump height of 0.15m**

Productivity Class 1	DBH Class (cm)	Age Class (years)															
		20		40		60		80		100		120		140		160	
		Total	Merch	Total	Merch	Total	Merch	Total	Merch	Total	Merch	Total	Merch	Total	Merch	Total	Merch
	2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	6	0.01	0.00	0.01	0.00	0.01	0.00	0.01	0.00	0.01	0.00	0.01	0.00	0.01	0.00	0.01	0.00
	8	0.01	0.00	0.02	0.00	0.02	0.00	0.02	0.00	0.02	0.00	0.03	0.00	0.03	0.00	0.03	0.00
	10	0.03	0.02	0.03	0.02	0.04	0.02	0.04	0.02	0.04	0.03	0.05	0.03	0.05	0.03	0.05	0.03
	12	0.04	0.03	0.05	0.04	0.06	0.05	0.07	0.05	0.07	0.05	0.07	0.05	0.07	0.06	0.07	0.06
	14	0.07	0.05	0.08	0.07	0.09	0.07	0.10	0.08	0.10	0.09	0.11	0.09	0.11	0.09	0.11	0.09
	16	0.09	0.08	0.11	0.10	0.12	0.11	0.13	0.12	0.14	0.12	0.15	0.13	0.15	0.13	0.15	0.13
	18	0.13	0.11	0.15	0.14	0.17	0.15	0.18	0.16	0.19	0.17	0.19	0.18	0.20	0.18	0.20	0.18
	20	0.17	0.15	0.20	0.18	0.22	0.20	0.23	0.21	0.24	0.22	0.25	0.23	0.25	0.23	0.25	0.23
	22	0.21	0.20	0.25	0.23	0.28	0.26	0.29	0.27	0.31	0.28	0.31	0.29	0.31	0.29	0.31	0.29
	24	0.27	0.25	0.31	0.29	0.34	0.32	0.36	0.34	0.38	0.35	0.38	0.36	0.38	0.36	0.38	0.36
	26	0.33	0.31	0.38	0.36	0.42	0.39	0.44	0.41	0.45	0.43	0.46	0.43	0.46	0.43	0.46	0.43
	28	0.39	0.37	0.46	0.43	0.50	0.47	0.52	0.50	0.54	0.51	0.54	0.51	0.54	0.51	0.54	0.51
	30	0.47	0.44	0.54	0.51	0.59	0.56	0.62	0.58	0.63	0.60	0.64	0.60	0.63	0.60	0.63	0.59
	32	0.55	0.52	0.64	0.60	0.69	0.65	0.72	0.68	0.73	0.69	0.74	0.70	0.73	0.69	0.72	0.68
	34	0.64	0.61	0.74	0.70	0.79	0.75	0.83	0.78	0.84	0.80	0.84	0.80	0.83	0.79	0.82	0.78
	36	0.74	0.70	0.85	0.81	0.91	0.86	0.94	0.90	0.95	0.91	0.96	0.91	0.95	0.90	0.93	0.88
	38	0.85	0.81	0.96	0.92	1.03	0.98	1.06	1.01	1.08	1.03	1.08	1.02	1.06	1.01	1.04	0.99
	40	0.96	0.92	1.09	1.04	1.16	1.11	1.20	1.14	1.21	1.15	1.20	1.15	1.19	1.13	1.16	1.11

(Cont'd)

Productivity Class 2	DBH Class (cm)	Age Class (years) 20		40		60		80		100		120		140		160	
		Total	Merch	Total	Merch	Total	Merch	Total	Merch	Total	Merch	Total	Merch	Total	Merch	Total	Merch
	2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	6	0.01	0.00	0.01	0.00	0.01	0.00	0.01	0.00	0.01	0.00	0.01	0.00	0.01	0.00	0.01	0.00
	8	0.01	0.00	0.02	0.00	0.02	0.00	0.02	0.00	0.02	0.00	0.02	0.00	0.02	0.00	0.02	0.00
	10	0.02	0.01	0.03	0.02	0.03	0.02	0.04	0.02	0.04	0.02	0.04	0.02	0.04	0.02	0.03	0.02
	12	0.04	0.03	0.05	0.04	0.06	0.04	0.06	0.05	0.06	0.05	0.06	0.05	0.06	0.05	0.06	0.04
	14	0.06	0.05	0.07	0.06	0.08	0.07	0.09	0.08	0.10	0.08	0.10	0.08	0.09	0.08	0.09	0.07
	16	0.08	0.07	0.10	0.09	0.11	0.10	0.13	0.11	0.14	0.12	0.14	0.12	0.14	0.12	0.13	0.11
	18	0.10	0.09	0.13	0.12	0.15	0.14	0.17	0.15	0.18	0.17	0.19	0.17	0.19	0.17	0.18	0.16
	20	0.13	0.12	0.17	0.15	0.20	0.18	0.22	0.20	0.24	0.22	0.25	0.23	0.25	0.23	0.24	0.22
	22	0.16	0.15	0.21	0.19	0.25	0.23	0.28	0.26	0.30	0.28	0.31	0.29	0.32	0.29	0.31	0.28
	24	0.20	0.18	0.25	0.24	0.30	0.28	0.34	0.32	0.37	0.34	0.39	0.36	0.39	0.37	0.38	0.36
	26	0.23	0.22	0.30	0.28	0.36	0.34	0.41	0.38	0.44	0.42	0.47	0.44	0.48	0.45	0.47	0.44
	28	0.27	0.26	0.35	0.33	0.42	0.40	0.48	0.45	0.53	0.50	0.56	0.53	0.58	0.54	0.57	0.54
	30	0.32	0.30	0.41	0.39	0.49	0.47	0.56	0.53	0.62	0.58	0.66	0.62	0.68	0.64	0.68	0.64
	32	0.36	0.34	0.47	0.45	0.57	0.54	0.65	0.61	0.71	0.68	0.76	0.72	0.79	0.75	0.79	0.75
	34	0.41	0.39	0.53	0.51	0.64	0.61	0.74	0.70	0.82	0.78	0.88	0.83	0.91	0.87	0.92	0.87
	36	0.46	0.44	0.60	0.57	0.73	0.69	0.83	0.79	0.93	0.88	1.00	0.95	1.04	0.99	1.05	1.00
	38	0.51	0.49	0.67	0.64	0.81	0.77	0.94	0.89	1.04	0.99	1.12	1.07	1.18	1.12	1.20	1.14
	40	0.57	0.54	0.75	0.71	0.90	0.86	1.04	0.99	1.16	1.11	1.26	1.20	1.32	1.26	1.35	1.29

(Cont'd)

Productivity Class 3	DBH Class (cm)	Age Class (years) 20		40		60		80		100		120		140		160	
		Total	Merch	Total	Merch	Total	Merch	Total	Merch	Total	Merch	Total	Merch	Total	Merch	Total	Merch
	2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	6	0.01	0.00	0.01	0.00	0.01	0.00	0.01	0.00	0.01	0.00	0.01	0.00	0.01	0.00	0.01	0.00
	8	0.01	0.00	0.02	0.00	0.02	0.00	0.02	0.00	0.02	0.00	0.02	0.00	0.02	0.00	0.02	0.00
	10	0.03	0.02	0.03	0.02	0.03	0.02	0.04	0.02	0.04	0.02	0.04	0.02	0.04	0.02	0.04	0.02
	12	0.04	0.03	0.05	0.04	0.05	0.04	0.06	0.04	0.06	0.05	0.06	0.05	0.06	0.05	0.07	0.05
	14	0.07	0.06	0.07	0.06	0.08	0.07	0.09	0.07	0.09	0.08	0.10	0.08	0.10	0.08	0.10	0.08
	16	0.10	0.08	0.11	0.10	0.12	0.10	0.13	0.11	0.13	0.12	0.13	0.12	0.14	0.12	0.14	0.12
	18	0.13	0.12	0.15	0.13	0.16	0.15	0.17	0.15	0.18	0.16	0.18	0.17	0.19	0.17	0.19	0.17
	20	0.18	0.16	0.20	0.18	0.21	0.20	0.22	0.21	0.23	0.21	0.24	0.22	0.24	0.22	0.24	0.22
	22	0.23	0.21	0.25	0.24	0.27	0.25	0.29	0.27	0.30	0.28	0.30	0.28	0.31	0.28	0.31	0.28
	24	0.29	0.27	0.32	0.30	0.34	0.32	0.36	0.34	0.37	0.35	0.38	0.35	0.38	0.35	0.38	0.35
	26	0.36	0.34	0.39	0.37	0.42	0.40	0.44	0.41	0.45	0.42	0.46	0.43	0.46	0.43	0.46	0.43
	28	0.44	0.41	0.48	0.45	0.51	0.48	0.53	0.50	0.54	0.51	0.55	0.52	0.55	0.52	0.54	0.51
	30	0.52	0.49	0.57	0.54	0.60	0.57	0.63	0.59	0.64	0.61	0.65	0.61	0.65	0.61	0.64	0.61
	32	0.62	0.59	0.67	0.64	0.71	0.67	0.73	0.70	0.75	0.71	0.75	0.71	0.75	0.71	0.74	0.70
	34	0.72	0.69	0.78	0.74	0.82	0.78	0.85	0.81	0.86	0.82	0.87	0.82	0.86	0.82	0.85	0.81
	36	0.84	0.80	0.90	0.86	0.95	0.90	0.98	0.93	0.99	0.94	0.99	0.94	0.98	0.94	0.97	0.92
	38	0.96	0.91	1.03	0.98	1.08	1.03	1.11	1.06	1.12	1.07	1.12	1.07	1.11	1.06	1.10	1.04
	40	1.09	1.04	1.17	1.12	1.22	1.17	1.25	1.19	1.26	1.21	1.26	1.20	1.25	1.19	1.23	1.17

Appendix 2. Variable density merchantable volume tables by productivity, density class. and species

CLASS 1, DENSITY HIGH, *ASPEN*

Age Class	volume (m^3/ha)	basal area (m^2/ha)	mean dbh (cm)	stems/ha	stems/m^3	MAI (m^3/ha/yr)
32.5	2.88	1.36	8.64	148.84	51.68	0.09
37.5	8.96	2.27	9.57	211.72	23.63	0.24
42.5	14.93	3.18	10.49	273.18	18.30	0.35
47.5	20.56	4.05	11.38	329.60	16.03	0.43
52.5	25.63	4.86	12.25	377.37	14.72	0.49
57.5	30.01	5.61	13.11	415.40	13.84	0.52
62.5	33.73	6.27	13.91	442.85	13.13	0.54
67.5	36.91	6.85	14.67	458.66	12.43	0.55
72.5	39.69	7.32	15.37	462.99	11.67	0.55
77.5	42.15	7.68	16.01	457.37	10.85	0.54
82.5	44.39	7.93	16.60	443.65	9.99	0.54
87.5	46.54	8.08	17.12	424.23	9.12	0.53
92.5	48.64	8.14	17.53	401.19	8.25	0.53
97.5	50.72	8.13	17.82	376.35	7.42	0.52
102.5	52.53	8.07	17.96	349.33	6.65	0.51
107.5	53.72	7.94	17.90	320.53	5.97	0.50
112.5	54.32	7.78	17.60	292.30	5.38	0.48
117.5	54.53	7.62	17.04	266.99	4.90	0.46
122.5	54.50	7.50	16.45	249.24	4.57	0.44
132.5	54.39	7.38	15.79	233.05	4.28	0.41

Merchantable volume tables (cont'd)

CLASS 1, DENSITY HIGH, *BALSAM*

Age Class	volume (m^3/ha)	basal area (m^2/ha)	mean dbh (cm)	stems/ha	stems/m^3	MAI (m^3/ha/yr)
32.5	4.09	1.54	8.83	161.42	39.47	0.13
37.5	10.17	2.45	9.76	224.22	22.05	0.27
42.5	16.09	3.36	10.67	285.02	17.71	0.38
47.5	21.62	4.22	11.55	339.90	15.72	0.46
52.5	26.56	5.02	12.43	385.78	14.52	0.51
57.5	30.81	5.75	13.27	421.77	13.69	0.54
62.5	34.40	6.40	14.07	446.95	12.99	0.55
67.5	37.50	6.95	14.81	460.40	12.28	0.56
72.5	40.21	7.40	15.50	462.62	11.51	0.55
77.5	42.61	7.73	16.13	455.18	10.68	0.55
82.5	44.82	7.97	16.71	440.15	9.82	0.54
87.5	46.96	8.10	17.22	419.82	8.94	0.54
92.5	49.06	8.15	17.60	396.37	8.08	0.53
97.5	51.12	8.13	17.86	371.13	7.26	0.52
102.5	52.82	8.05	17.96	343.64	6.51	0.52
107.5	53.88	7.91	17.86	314.74	5.84	0.50
112.5	54.38	7.75	17.50	286.95	5.28	0.48
117.5	54.53	7.59	16.90	262.35	4.81	0.46
122.5	54.48	7.47	16.29	245.07	4.50	0.44
132.5	54.36	7.36	15.61	229.17	4.22	0.41

Merchantable volume tables (cont'd)

CLASS 1, DENSITY HIGH, *BIRCH*

Age Class	volume (m^3/ha)	basal area (m^2/ha)	mean dbh (cm)	stems/ha	stems/m^3	MAI (m^3/ha/yr)
32.5	5.31	1.73	9.02	174.02	32.77	0.16
37.5	11.37	2.64	9.94	2236.66	20.81	0.30
42.5	17.24	3.53	10.85	296.64	17.21	0.41
47.5	22.66	4.39	11.73	349.87	15.44	0.48
52.5	27.47	5.17	12.60	393.83	14.34	0.52
57.5	31.58	5.88	13.44	427.75	13.54	0.55
62.5	35.06	6.52	14.22	450.63	12.85	0.56
67.5	38.07	7.05	14.95	461.72	12.13	0.56
72.5	40.71	7.47	15.63	461.91	11.35	0.56
77.5	43.06	7.79	16.25	452.73	10.51	0.56
82.5	45.26	8.00	16.82	436.48	9.64	0.55
87.5	47.38	8.12	17.30	415.31	8.77	0.54
92.5	49.49	8.15	17.66	391.52	7.91	0.54
97.5	51.50	8.12	17.89	365.85	7.10	0.53
102.5	53.09	8.02	17.96	337.93	6.37	0.52
107.5	54.02	7.88	17.81	309.03	5.72	0.50
112.5	54.43	7.71	17.40	281.75	5.18	0.48
117.5	54.53	7.56	16.75	257.86	4.73	0.46
122.5	54.45	7.44	16.12	240.99	4.43	0.44
132.5	54.34	7.33	15.44	225.33	4.15	0.41

Merchantable volume tables (cont'd)

CLASS 1, DENSITY HIGH, *BLACK SPRUCE*

Age Class	volume (m^3/ha)	basal area (m^2/ha)	mean dbh (cm)	stems/ha	stems/m^3	MAI (m^3/ha/yr)
32.5	6.53	1.91	9.20	186.61	28.58	0.20
37.5	12.57	2.82	10.13	248.99	19.81	0.34
42.5	18.37	3.71	11.02	307.97	16.76	0.43
47.5	23.68	4.55	11.91	359.45	15.18	0.50
52.5	28.35	5.32	12.77	401.47	14.16	0.54
57.5	32.32	6.02	13.60	433.28	13.41	0.56
62.5	35.70	6.63	14.37	453.84	12.71	0.57
67.5	38.62	7.14	15.09	462.61	11.98	0.57
72.5	41.21	7.55	15.76	460.80	11.18	0.57
77.5	43.51	7.84	16.37	450.00	10.34	0.56
82.5	45.69	8.04	16.93	432.62	9.47	0.55
87.5	47.80	8.13	17.38	410.70	8.59	0.55
92.5	49.91	8.15	17.72	386.58	7.75	0.54
97.5	51.87	8.10	17.92	360.48	6.95	0.53
102.5	53.33	8.00	17.95	332.18	6.23	0.52
107.5	54.14	7.85	17.75	303.39	5.60	0.50
112.5	54.48	7.68	17.29	276.70	5.08	0.48
117.5	54.52	7.53	16.60	253.51	4.65	0.46
122.5	54.42	7.41	15.96	236.99	4.35	0.44
132.5	54.32	7.30	15.27	221.53	4.08	0.41

Merchantable volume tables (cont'd)

CLASS 1, DENSITY HIGH, *JACK PINE*

Age Class	volume (m^3/ha)	basal area (m^2/ha)	mean dbh (cm)	stems/ha	stems/m^3	MAI (m^3/ha/yr)
32.5	7.74	2.09	9.39	199.18	25.73	0.24
37.5	13.75	3.00	10.31	261.16	18.99	0.37
42.5	19.48	3.88	11.20	318.96	16.37	0.46
47.5	24.67	4.71	12.908	368.60	14.94	0.52
52.5	29.19	5.46	12.94	408.65	14.00	0.56
57.5	33.04	6.15	13.76	438.30	13.27	0.57
62.5	36.31	6.74	14.52	456.49	12.57	0.58
67.5	39.16	7.23	15.23	463.01	11.82	0.58
72.5	41.68	7.61	15.88	459.27	11.02	0.57
77.5	43.95	7.89	16.49	446.95	10.17	0.57
82.5	46.12	8.06	17.03	428.52	9.29	0.56
87.5	48.22	8.14	17.46	405.98	8.42	0.55
92.5	50.32	8.14	17.77	381.51	7.58	0.54
97.5	52.21	8.09	17.94	354.96	6.80	0.54
102.5	53.54	7.97	17.93	326.37	6.10	0.52
107.5	54.24	7.81	17.68	297.80	5.49	0.50
112.5	54.51	7.65	17.17	271.77	4.99	0.48

Merchantable volume tables (cont'd)

CLASS 1, DENSITY MEDIUM, *ASPEN*

Age Class	volume (m^3/ha)	basal area (m^2/ha)	mean dbh (cm)	stems/ha	stems/m^3	MAI (m^3/ha/yr)
32.5	8.44	2.40	10.01	192.60	22.82	0.26
37.5	12.43	3.37	11.83	260.63	20.97	0.33
42.5	16.63	4.31	13.23	319.27	19.20	0.39
47.5	21.02	5.18	14.27	364.27	17.33	0.44
52.5	25.50	5.96	15.04	393.76	15.44	0.49
57.5	31.12	6.77	15.83	410.48	13.19	0.54
62.5	36.47	7.39	16.51	407.89	11.18	0.58
67.5	41.13	7.80	17.17	391.03	9.51	0.61
72.5	44.67	7.99	17.94	363.94	8.15	0.62
77.5	47.06	7.98	18.88	328.66	6.98	0.61
82.5	48.41	7.79	19.96	288.54	5.96	0.59
87.5	49.32	7.55	21.08	249.30	5.05	0.56
92.5	50.14	7.39	21.96	222.32	4.43	0.54
97.5	50.92	7.20	22.97	194.26	3.82	0.52
102.5	50.77	6.95	23.82	170.93	3.37	0.50
107.5	49.56	6.59	24.48	150.98	3.05	0.46
112.5	47.75	6.18	24.95	134.03	2.81	0.42
117.5	46.25	5.85	25.23	122.31	2.64	0.39

Merchantable volume tables (cont'd)

CLASS 1, DENSITY MEDIUM, *BALSAM*

Age Class	volume (m^3/ha)	basal area (m^2/ha)	mean dbh (cm)	stems/ha	stems/m^3	MAI (m^3/ha/yr)
52.5	26.63	6.13	15.21	398.82	14.98	0.51
57.5	32.23	6.92	15.97	411.35	12.76	0.56
62.5	37.48	7.49	16.64	405.50	10.82	0.60
67.5	41.94	7.85	17.31	386.35	9.21	0.62
72.5	45.24	8.00	18.12	357.46	7.90	0.62
77.5	47.39	7.95	19.09	320.86	6.77	0.61
87.5	49.51	7.50	21.30	242.13	4.89	0.57
92.5	50.34	7.35	22.17	216.25	4.30	0.54
97.5	50.98	7.16	23.16	189.27	3.71	0.52
102.5	50.60	6.88	23.97	166.69	3.29	0.49
107.5	49.22	6.51	24.58	147.35	2.99	0.46
112.5	47.37	6.09	25.03	130.98	2.77	0.42
117.5	45.89	5.77	25.29	119.53	2.60	0.39

Merchantable volume tables (cont'd)

CLASS 1, DENSITY MEDIUM, *BIRCH*

Age Class	volume (m^3/ha)	basal area (m^2/ha)	mean dbh (cm)	stems/ha	stems/m^3	MAI (m^3/ha/yr)
32.5	9.42	2.64	10.51	210.25	22.32	0.29
37.5	13.46	3.61	12.2[illegible]	276.37	20.53	0.36
42.5	17.72	4.53	13.52	331.94	18.73	0.42
52.5	27.76	6.30	15.37	403.06	14.52	0.53
57.5	33.32	7.05	16.11	411.51	12.35	0.58
62.5	38.45	7.58	16.77	402.60	10.47	0.62
67.5	42.69	7.90	17.46	381.32	8.93	0.63
72.5	45.76	8.01	18.30	350.69	7.66	0.63
77.5	47.70	7.92	19.30	312.91	6.56	0.62
82.5	48.78	7.69	20.41	272.36	5.58	0.59
87.5	49.72	7.46	21.52	235.24	4.73	0.57
92.5	50.52	7.32	22.38	210.43	4.17	0.55
97.5	51.00	7.11	23.34	184.46	3.62	0.52
102.5	50.39	6.82	24.11	162.58	3.23	0.49
107.5	48.87	6.43	24.69	143.85	2.94	0.45
112.5	46.99	6.01	25.10	128.02	2.72	0.42
117.5	45.53	5.68	25.35	116.78	2.56	0.39

Merchantable volume tables (cont'd)

CLASS 1, DENSITY MEDIUM, *BLACK SPRUCE*

Age Class	volume (m^3/ha)	basal area (m^2/ha)	mean dbh (cm)	stems/ha	stems/m^3	MAI (m^3/ha/yr)
32.5	10.41	2.89	10.98	227.51	21.85	0.32
37.5	14.50	3.85	12.58	291.44	20.10	0.39
42.5	18.81	4.76	13.79	343.71	18.27	0.44
47.5	23.26	5.58	14.68	380.99	16.38	0.49
52.5	28.89	6.47	15.53	406.42	14.07	0.55
57.5	34.39	7.17	16.24	410.97	11.95	0.60
62.5	39.39	7.66	16.90	399.22	10.14	0.63
67.5	43.40	7.94	17.61	375.92	8.66	0.64
72.5	46.24	8.01	18.49	343.63	7.43	0.64
77.5	47.96	7.88	19.52	304.86	6.36	0.62
82.5	48.95	7.64	20.63	264.47	5.40	0.59
87.5	49.93	7.42	21.74	228.65	4.58	0.57
92.5	50.69	7.28	22.58	204.83	4.04	0.55
97.5	50.97	7.06	23.51	179.81	3.53	0.52
102.5	50.15	6.74	24.24	158.59	3.16	0.49
107.5	48.51	6.35	24.78	140.47	2.90	0.45
117.5	45.18	5.60	25.41	114.05	2.52	0.38

Merchantable volume tables (cont'd)

CLASS 1, DENSITY MEDIUM, *JACK PINE*

Age Class	volume (m^3/ha)	basal area (m^2/ha)	mean dbh (cm)	stems/ha	stems/m^3	MAI (m^3/ha/yr)
32.5	11.41	3.13	11.42	244.32	21.41	0.35
37.5	15.56	4.08	12.92	305.75	19.65	0.41
47.5	24.38	5.77	14.86	387.84	15.91	0.51
52.5	30.01	6.63	15.68	408.86	13.62	0.57
57.5	35.45	7.29	16.38	409.74	11.56	0.62
62.5	40.28	7.73	17.04	395.34	9.81	0.64
67.5	44.06	7.97	17.77	370.11	8.40	0.65
72.5	46.67	8.00	18.68	336.27	7.21	0.64
77.5	48.20	7.84	19.74	296.71	6.16	0.62
82.5	49.13	7.59	20.86	256.76	5.23	0.60
92.5	50.82	7.24	22.78	199.45	3.92	0.55
97.5	50.90	7.01	23.67	175.30	3.44	0.52
102.5	49.87	6.67	24.36	154.72	3.10	0.49
107.5	48.13	6.26	24.87	137.19	2.85	0.45

Merchantable volume tables (cont'd)

CLASS 2, DENSITY HIGH, *ASPEN*

Age Class	volume (m^3/ha)	basal area (m^2/ha)	mean dbh (cm)	stems/ha	stems/m^3	MAI (m^3/ha/yr)
7.5	0.00	0.00	0.00	0.00	.*	0.00
12.5	0.00	0.00	1.13	0.00	.	0.00
17.5	0.00	0.00	2.63	0.00	.	0.00
22.5	0.08	0.12	4.10	18.37	.	0.00
27.5	1.06	0.47	5.96	55.59	52.44	0.04
37.5	2.29	0.90	7.62	98.42	42.98	0.06
42.5	4.30	1.53	9.39	159.79	37.16	0.10
47.5	6.85	2.25	10.87	224.63	32.79	0.14
52.5	8.59	2.69	11.61	260.91	30.37	0.16
57.5	10.48	3.12	12.26	293.32	27.99	0.18
62.5	13.97	3.81	13.19	339.26	24.28	0.22
67.5	17.81	4.49	13.98	375.31	21.07	0.26
77.5	24.79	5.54	15.24	409.97	16.54	0.32
82.5	28.32	6.01	15.93	413.15	14.59	0.34
87.5	31.26	6.35	16.60	407.48	13.04	0.36
92.5	33.49	6.55	17.19	397.47	11.87	0.36
97.5	35.18	6.64	17.69	387.15	11.00	0.36
102.5	36.39	6.63	18.05	376.29	10.34	0.36
107.5	37.39	6.60	18.21	367.53	9.83	0.35
112.5	38.61	6.63	18.12	363.95	9.43	0.34

Merchantable volume tables (cont'd)

CLASS 2, DENSITY HIGH, *BALSAM*

Age Class	volume (m^3/ha)	basal area (m^2/ha)	mean dbh (cm)	stems/ha	stems/m^3	MAI (m^3/ha/yr)
22.5	0.30	0.20	4.58	27.22	90.7	0.01
27.5	1.34	0.57	6.40	65.74	49.06	0.05
37.5	2.65	1.02	8.00	110.06	41.53	0.07
42.5	4.77	1.67	9.71	172.79	36.22	0.11
57.5	11.14	3.26	12.46	303.29	27.23	0.19
62.5	14.71	3.95	13.35	347.29	23.61	0.24
67.5	18.60	4.62	14.13	381.15	20.49	0.28
72.5	21.73	5.10	14.69	399.35	18.38	0.30
77.5	25.53	5.64	15.38	411.46	16.12	0.33
82.5	28.97	6.09	16.06	412.60	14.24	0.35
87.5	31.76	6.40	16.72	405.63	12.77	0.36
92.5	33.87	6.58	17.30	395.44	11.68	0.37
97.5	35.46	6.65	17.77	384.97	10.86	0.36
102.5	36.59	6.63	18.09	374.24	10.23	0.36
107.5	37.61	6.60	18.21	366.33	9.74	0.35
112.5	38.90	6.64	18.07	363.94	9.36	0.35

Merchantable volume tables (cont'd)

CLASS 2, DENSITY HIGH, *BIRCH*

Age Class	volume (m^3/ha)	basal area (m^2/ha)	mean dbh (cm)	stems/ha	stems/m^3	MAI (m^3/ha/yr)
7.5	0.00	0.00	0.14	0.00	.	0.00
12.5	0.00	0.00	1.63	0.00	.	0.00
17.5	0.00	0.00	3.12	1.40	.	0.00
22.5	0.54	0.29	5.06	36.35	67.31	0.02
27.5	1.64	0.68	6.82	76.26	46.50	0.06
42.5	5.26	1.81	10.02	185.89	35.34	0.12
57.5	11.82	3.40	12.65	312.89	26.47	0.21
62.5	15.47	4.09	13.52	354.97	22.95	0.25
72.5	22.51	5.22	14.83	402.77	17.89	0.31
77.5	26.26	5.74	15.51	412.56	15.71	0.34
82.5	29.59	6.16	16.20	411.78	13.92	0.36
87.5	32.23	6.45	16.85	403.68	12.52	0.37
92.5	34.24	6.60	17.41	393.47	11.49	0.37
97.5	35.72	6.65	17.85	382.82	10.72	0.37
102.5	36.79	6.62	18.14	372.37	10.12	0.36
107.5	37.84	6.60	18.20	365.41	9.66	0.35
112.5	39.22	6.66	18.02	364.16	9.29	0.35

Merchantable volume tables (cont'd)

CLASS 2, DENSITY HIGH, *BLACK SPRUCE*

Age Class	volume (m^3/ha)	basal area (m^2/ha)	mean dbh (cm)	stems/ha	stems/m^3	MAI (m^3/ha/yr)
7.5	0.00	0.00	0.64	0.00	.	0.00
12.5	0.00	0.00	2.13	0.00	.	0.00
17.5	0.00	0.04	3.62	9.78	.	0.00
22.5	0.79	0.38	5.52	45.80	57.97	0.04
27.5	1.95	0.78	7.23	87.15	44.69	0.07
37.5	3.43	1.26	8.72	134.37	39.17	0.09
42.5	5.77	1.96	10.31	198.96	34.48	0.14
47.5	7.41	2.40	11.13	237.09	32.00	0.16
52.5	9.20	2.83	11.84	272.18	29.58	0.18
57.5	12.52	3.54	12.84	322.10	25.73	0.22
67.5	19.38	4.74	14.27	386.48	19.94	0.29
72.5	23.28	5.33	14.97	405.70	17.43	0.32
77.5	26.97	5.84	15.65	413.22	15.32	0.35
82.5	30.18	6.23	16.33	410.65	13.61	0.37
87.5	32.68	6.48	16.97	401.66	12.29	0.37
92.5	34.58	6.62	17.50	391.46	11.32	0.37
97.5	35.96	6.65	17.92	380.67	10.59	0.37
102.5	37.00	6.61	18.17	370.63	10.02	0.36
107.5	38.08	6.61	18.18	364.72	9.58	0.35
112.5	39.55	6.68	7.98	364.52	9.22	0.35

Merchantable volume tables (cont'd)

CLASS 2, DENSITY HIGH, *JACK PINE*

Age Class	volume (m^3/ha)	basal area (m^2/ha)	mean dbh (cm)	stems/ha	stems/m^3	MAI (m^3/ha/yr)
37.5	3.85	1.40	9.07	146.96	38.17	0.10
42.5	6.30	2.10	10.59	211.89	33.63	0.15
47.5	7.99	2.54	11.37	249.20	31.19	0.17
52.5	9.83	2.97	12.06	282.97	28.79	0.19
57.5	13.23	3.68	13.01	330.87	25.01	0.23
67.5	20.17	4.86	14.42	391.24	19.40	0.30
72.5	24.04	5.44	15.10	408.07	16.97	0.33
77.5	27.66	5.92	15.79	413.39	14.95	0.36
82.5	30.73	6.29	16.47	409.18	13.32	0.37
87.5	33.10	6.52	17.08	399.56	12.07	0.38
92.5	34.89	6.63	17.60	389.33	11.16	0.38
97.5	36.18	6.64	17.99	378.46	10.46	0.37
102.5	37.19	6.61	18.19	368.99	9.92	0.36

CLASS 2, DENSITY MEDIUM, *ASPEN*

Age Class	volume (m^3/ha)	basal area (m^2/ha)	mean dbh (cm)	stems/ha	stems/m^3	MAI (m^3/ha/yr)
72.5	28.35	4.98	8.08	297.96	10.51	0.39
77.5	28.23	6.34	11.34	373.20	13.22	0.36
87.5	40.45	8.75	13.73	495.72	12.26	0.46

Merchantable volume tables (cont'd)

CLASS 2, DENSITY MEDIUM, *BALSAM*

Age Class	volume (m^3/ha)	basal area (m^2/ha)	mean dbh (cm)	stems/ha	stems/m^3	MAI (m^3/ha/yr)
72.5	28.09	5.29	8.74	314.86	11.21	0.39
77.5	28.69	6.59	11.82	387.01	13.49	0.37
82.5	33.56	7.72	13.33	447.95	13.35	0.41
87.5	43.20	9.10	13.59	510.88	11.83	0.49
92.5	53.55	10.42	12.62	568.27	10.61	0.58
102.5	64.36	11.76	12.11	616.86	9.58	0.63
107.5	70.64	12.32	12.40	612.94	8.68	0.66
112.5	69.91	11.74	12.83	551.32	7.89	0.62
117.5	65.12	10.68	13.32	482.57	7.41	0.55
122.5	54.85	8.67	14.07	367.57	6.70	0.45
132.5	47.64	7.27	14.50	289.96	6.09	0.36

CLASS 2, DENSITY MEDIUM, *BIRCH*

Age Class	volume (m^3/ha)	basal area (m^2/ha)	mean dbh (cm)	stems/ha	stems/m^3	MAI (m^3/ha/yr)
72.5	27.98	5.60	9.43	332.05	11.87	0.39
77.5	29.51	6.87	12.28	402.93	13.65	0.38
82.5	35.62	8.05	13.57	464.31	13.04	0.43
87.5	46.36	9.50	13.31	528.42	11.40	0.53
92.5	57.38	10.91	12.35	588.46	10.26	0.62
102.5	67.16	12.06	12.15	622.20	9.26	0.66
107.5	71.20	12.25	12.53	598.35	8.40	0.66
117.5	61.93	10.04	13.59	444.86	7.18	0.53
132.5	44.44	6.63	14.73	253.10	5.70	0.34

Merchantable volume tables (cont'd)

CLASS 2, DENSITY MEDIUM, *BLACK SPRUCE*

Age Class	volume (m^3/ha)	basal area (m^2/ha)	mean dbh (cm)	stems/ha	stems/m^3	MAI (m^3/ha/yr)
72.5	27.99	5.89	10.13	348.07	12.44	0.39
77.5	30.64	7.16	12.69	419.21	13.68	0.40
87.5	49.87	9.95	12.96	548.18	10.99	0.57
92.5	61.12	11.38	12.17	606.05	9.92	0.66
102.5	69.37	12.27	12.27	621.66	8.96	0.68
107.5	71.04	12.07	12.66	578.36	8.14	0.66
112.5	67.92	11.27	13.06	519.00	7.64	0.60
117.5	58.52	9.37	13.84	406.79	6.95	0.50
122.5	51.17	7.96	14.29	328.40	6.42	0.42
132.5	41.52	6.03	14.98	217.67	5.24	0.31

CLASS 2, DENSITY MEDIUM, *JACK PINE*

Age Class	volume (m^3/ha)	basal area (m^2/ha)	mean dbh (cm)	stems/ha	stems/m^3	MAI (m^3/ha/yr)
72.5	28.03	6.12	10.78	360.94	12.88	0.39
77.5	31.94	7.43	13.05	433.42	13.57	0.41

Merchantable volume tables (cont'd)

CLASS 3, DENSITY HIGH, *ASPEN*

Age Class	volume (m^3/ha)	basal area (m^2/ha)	mean dbh (cm)	stems/ha	stems/m^3	MAI (m^3/ha/yr)
32.5	0.00	0.00	8.87	0.00	.	0.00
37.5	0.00	0.00	8.81	0.00	.	0.00
42.5	0.53	0.35	8.79	42.74	80.64	0.01
47.5	2.32	0.96	8.76	106.54	45.92	0.05
52.5	5.07	1.81	8.68	191.70	37.81	0.10
57.5	7.90	2.61	8.59	269.39	34.10	0.14
67.5	13.90	4.12	8.45	409.31	29.45	0.21
72.5	19.41	5.34	8.41	514.44	26.50	0.27
77.5	22.29	5.92	8.44	562.28	25.23	0.29
82.5	28.32	7.08	8.48	651.54	23.01	0.34
87.5	33.48	8.01	8.43	718.51	21.46	0.38
92.5	39.31	9.00	8.36	782.33	19.90	0.42
102.5	45.90	10.02	8.36	839.04	18.28	0.45
107.5	53.28	11.07	8.46	885.53	16.62	0.50
112.5	61.43	12.15	8.65	919.71	14.97	0.55
117.5	70.26	13.23	8.93	942.41	13.41	0.60
122.5	79.73	14.35	9.30	957.96	12.02	0.65
132.5	90.01	15.57	9.77	974.26	10.82	0.68

Merchantable volume tables (cont'd)

CLASS 3, DENSITY HIGH, *BIRCH*

Age Class	volume (m^3/ha)	basal area (m^2/ha)	mean dbh (cm)	stems/ha	stems/m^3	MAI (m^3/ha/yr)
32.5	0.00	0.00	8.85	0.00	.	0.00
37.5	0.00	0.00	8.80	5.18	.	0.00
42.5	0.91	0.49	8.78	56.97	62.60	0.02
47.5	2.90	1.15	8.74	125.72	43.35	0.06
52.5	5.94	2.06	8.65	216.49	36.45	0.11
57.5	8.98	2.90	8.56	297.07	33.08	0.16
67.5	15.24	4.43	8.44	436.65	28.65	0.23
77.5	23.75	6.21	8.45	585.15	24.64	0.31
82.5	29.97	7.38	8.47	673.91	22.49	0.36
87.5	35.34	8.34	8.40	740.36	20.95	0.40
92.5	41.42	9.34	8.36	802.18	19.37	0.45
102.5	48.27	10.37	8.38	855.84	17.73	0.47
107.5	55.92	11.43	8.51	898.32	16.06	0.52
112.5	64.30	12.51	8.73	928.42	14.44	0.57
117.5	73.3	13.60	9.05	948.05	12.93	0.62
122.5	83.05	14.74	9.45	962.86	11.59	0.68
132.5	93.64	16.00	9.94	981.05	10.48	0.71

Merchantable volume tables (cont'd)

CLASS 3, DENSITY HIGH, *BLACK SPRUCE*

Age Class	volume (m^3/ha)	basal area (m^2/ha)	mean dbh (cm)	stems/ha	stems/m^3	MAI (m^3/ha/yr)
32.5	0.00	0.00	8.83	0.00	.	0.00
37.5	0.00	0.11	8.79	16.99	.	0.00
42.5	1.33	0.63	8.78	72.28	54.35	0.03
47.5	3.55	1.35	8.72	146.32	41.22	0.07
52.5	6.88	2.33	8.62	242.49	35.25	0.13
57.5	10.13	3.20	8.53	325.24	32.11	0.18
62.5	12.60	3.81	8.48	381.59	30.28	0.20
67.5	16.61	4.74	8.42	463.42	27.90	0.25
72.5	20.85	5.63	8.42	538.84	25.84	0.29
77.5	25.23	6.50	8.47	607.58	24.08	0.33
82.5	31.69	7.70	8.45	696.40	21.98	0.38
87.5	37.29	8.67	8.38	761.79	20.43	0.43
92.5	43.62	9.68	8.36	821.23	18.83	0.47
102.5	50.74	10.72	8.41	871.48	17.18	0.50
107.5	58.64	11.79	8.57	909.83	15.52	0.55
112.5	67.26	12.87	8.83	936.07	13.92	0.60
117.5	76.51	13.98	9.17	953.28	12.46	0.65
122.5	86.49	15.15	9.61	968.33	11.20	0.71
132.5	97.35	16.45	10.12	988.61	10.16	0.73

Merchantable volume tables (cont'd)

CLASS 3, DENSITY HIGH, *JACK PINE*

Age Class	volume (m^3/ha)	basal area (m^2/ha)	mean dbh (cm)	stems/ha	stems/m^3	MAI (m^3/ha/yr)
32.5	0.00	0.00	8.82	0.00	.	0.00
37.5	0.19	0.23	8.79	29.46	.	0.01
42.5	1.79	0.79	8.77	88.76	49.59	0.04
47.5	4.27	1.57	8.70	168.30	39.41	0.09
57.5	11.34	3.50	8.50	353.48	31.17	0.20
67.5	18.00	5.04	8.41	489.30	27.18	0.27
77.5	26.75	6.78	8.48	629.53	23.53	0.35

CLASS 3, DENSITY MEDIUM, *ASPEN*

Age Class	volume (m^3/ha)	basal area (m^2/ha)	mean dbh (cm)	stems/ha	stems/m^3	MAI (m^3/ha/yr)
32.5	0.07	0.00	7.21	0.00	0.00	0.00
37.5	0.07	0.11	8.79	14.99	.	0.00
42.5	0.08	0.27	9.79	42.22	.	0.00
47.5	0.18	0.48	10.31	77.12	.	0.00
52.5	0.99	0.92	10.38	138.88	.	0.02
67.5	9.09	2.96	9.48	314.14	34.56	0.13
77.5	33.92	7.79	9.50	574.95	16.95	0.44

Merchantable volume tables (cont'd)

CLASS 3, DENSITY MEDIUM, *BALSAM*

Age Class	volume (m^3/ha)	basal area (m^2/ha)	mean dbh (cm)	stems/ha	stems/m^3	MAI (m^3/ha/yr)
32.5	0.07	0.00	7.53	0.00	0.00	0.00
47.5	0.25	0.55	10.37	87.69	.	0.01
57.5	3.27	1.60	9.96	208.53	63.77	0.06
67.5	11.37	3.45	9.42	347.11	30.53	0.17
72.5	20.64	5.33	9.41	457.70	22.18	0.28
77.5	39.30	8.75	9.50	614.56	15.64	0.51
82.5	58.04	11.96	9.48	732.40	12.62	0.70
102.5	95.09	17.67	9.54	868.66	9.14	0.93
107.5	102.46	18.51	9.73	855.04	8.35	0.95
112.5	106.85	18.78	10.10	814.61	7.62	0.95
117.5	108.69	18.57	10.64	753.50	6.93	0.93
122.5	108.68	18.03	11.37	678.56	6.24	0.89
132.5	107.81	17.33	12.21	597.08	5.54	0.81

CLASS 3, DENSITY MEDIUM, *BIRCH*

Age Class	volume (m^3/ha)	basal area (m^2/ha)	mean dbh (cm)	stems/ha	stems/m^3	MAI (m^3/ha/yr)
32.5	0.07	0.00	7.85	0.00	0.00	0.00
37.5	0.07	0.15	9.08	21.32	.	0.00
42.5	0.09	0.31	9.97	50.08	.	0.00
47.5	0.36	0.62	10.41	99.20	.	0.01
57.5	4.31	1.87	9.82	231.22	53.65	0.07
67.5	14.05	4.01	9.39	382.56	27.23	0.21
77.5	45.15	9.77	9.50	654.58	14.50	0.58
82.5	64.85	13.09	9.47	768.42	11.85	0.79

Merchantable volume tables (cont'd)

CLASS 3, DENSITY MEDIUM, *BLACK SPRUCE*

Age Class	volume (m^3/ha)	basal area (m^2/ha)	mean dbh (cm)	stems/ha	stems/m^3	MAI (m^3/ha/yr)
32.5	0.07	0.04	8.17	2.96	42.29	0.00
37.5	0.07	0.19	9.34	27.93	.	0.00
42.5	0.11	0.36	10.12	58.47	.	0.00
47.5	0.51	0.71	10.42	111.59	.	0.01
52.5	1.36	1.05	10.31	154.04	.	0.03
57.5	5.60	2.18	9.69	256.40	45.79	0.10
67.5	17.14	4.64	9.39	419.72	24.49	0.25
72.5	29.03	6.90	9.48	535.71	18.45	0.40
77.5	51.44	10.85	9.49	694.27	13.50	0.66
82.5	71.70	14.20	9.46	801.22	11.17	0.87
87.5	84.63	16.21	9.47	850.46	10.05	0.97
92.5	90.24	17.02	9.50	863.84	9.57	0.98
102.5	99.17	18.17	9.62	865.60	8.73	0.97
107.5	105.01	18.72	9.89	837.87	7.98	0.98
112.5	108.06	18.73	10.35	786.27	7.28	0.96
117.5	108.87	18.33	10.99	717.36	6.59	0.93
122.5	108.29	17.69	11.78	638.23	5.89	0.88
132.5	107.31	16.97	12.66	555.76	5.18	0.81

Merchantable volume tables (cont'd)

CLASS 3, DENSITY MEDIUM, *JACK PINE*

Age Class	volume (m^3/ha)	basal area (m^2/ha)	mean dbh (cm)	stems/ha	stems/m^3	MAI (m^3/ha/yr)
32.5	0.07	0.07	8.48	8.89	.	0.00
37.5	0.07	0.23	9.58	34.86	.	0.00
42.5	0.13	0.42	10.23	67.43	.	0.00
47.5	0.72	0.81	10.42	124.76	.	0.02
52.5	1.84	1.21	10.22	170.33	92.57	0.04
57.5	7.18	2.54	9.57	283.94	39.55	0.12

CLASS 1, DENSITY HIGH, All species

Age Class	volume (m^3/ha)	MAI (m^3/ha/yr)
32.5	31.98	0.98
37.5	61.67	1.64
42.5	90.31	2.12
47.5	116.79	2.46
52.5	140.36	2.67
62.5	177.60	2.84
57.5	192.63	2.85
72.5	206.08	2.84
77.5	218.04	2.81
82.5	229.15	2.78
87.5	239.49	2.74
92.5	248.53	2.69
97.5	254.94	2.61
102.5	256.99	2.51
107.5	253.45	2.36
112.5	245.44	2.18
117.5	234.66	2.00
122.5	222.36	1.82
132.5	209.71	1.58

CLASS 1, DENSITY MEDIUM, All species

Age Class	volume (m^3/ha)	MAI (m^3/ha/yr)
32.5	42.65	1.31
37.5	61.45	1.64
42.5	83.53	1.97
47.5	108.22	2.28
52.5	134.38	2.56
57.5	160.53	2.79
62.5	184.82	2.96
67.5	205.52	3.04
72.5	221.20	3.05
77.5	231.54	2.99
82.5	237.60	2.88
87.5	241.61	2.76
92.5	244.48	2.64
97.5	243.50	2.50
102.5	236.45	2.31
107.5	223.41	2.08
112.5	206.14	1.83
117.5	187.17	1.59

CLASS 2, DENSITY HIGH, All species

Age Class	volume (m^3/ha)	MAI (m^3/ha/yr)
7.5	0.00	0.00
12.5	0.00	0.00
17.5	0.00	0.00
22.5	1.99	0.09
27.5	6.17	0.22
37.5	12.08	0.32
42.5	20.10	0.47
47.5	30.40	0.64
52.5	43.16	0.82
57.5	58.28	1.01
62.5	75.50	1.21
67.5	94.20	1.40
72.5	113.43	1.56
77.5	132.02	1.70
82.5	148.39	1.80
87.5	161.05	1.84
92.5	169.43	1.83
97.5	173.37	1.78
102.5	172.86	1.69
107.5	168.80	1.57
112.5	162.82	1.45

CLASS 2, DENSITY MEDIUM, All species

Age Class	volume (m^3/ha)	MAI (m^3/ha/yr)
72.5	146.29	2.02
77.5	147.96	1.91
82.5	154.12	1.87
87.5	169.54	1.94
92.5	189.76	2.05
102.5	201.66	1.97
107.5	196.34	1.83
112.5	176.73	1.57
117.5	146.70	1.25
122.5	112.88	0.92
132.5	83.36	0.63

CLASS 3, DENSITY HIGH,
All species

Age Class	volume (m^3/ha)	MAI (m^3/ha/yr)
32.5	0.00	0.00
37.5	0.00	0.00
42.5	4.49	0.11
47.5	10.19	0.21
52.5	17.59	0.34
57.5	27.13	0.47
67.5	53.28	0.79
72.5	68.79	0.95
77.5	84.80	1.09
82.5	101.08	1.23
87.5	118.22	1.35
92.5	136.87	1.48
102.5	156.92	1.53
107.5	177.37	1.65
112.5	196.47	1.75
117.5	212.24	1.81
122.5	224.28	1.83
132.5	234.35	1.77

CLASS 3, DENSITY MEDIUM,
All species

Age Class	volume (m^3/ha)	MAI (m^3/ha/yr)
32.5	0.00	0.00
37.5	0.00	0.00
42.5	3.36	0.08
47.5	10.22	0.22
52.5	20.10	0.38
57.5	34.23	0.60
67.5	53.59	0.79
72.5	78.46	1.08
77.5	108.84	1.40
82.5	143.42	1.74
87.5	177.64	2.03
92.5	205.34	2.22
102.5	223.11	2.18
107.5	229.41	2.13
112.5	223.69	1.99
117.5	206.29	1.76
122.5	179.98	1.47
132.5	149.95	1.13

Appendix 3. Merchantable volume tables by species composition, productivity class, and species.

CLASS 1, COMPOSITION MIXED, *ASPEN*

Age Class	volume (m^3/ha)	basal area (m^2/ha)	avg dbh (cm)	stems/ha	stems/m^3	MAI (m^3/ha/yr)
12.5	0.00	0.00	3.37	0.00	.*	0.00
17.5	0.00	0.19	4.51	30.87	.	0.00
22.5	2.34	0.70	5.62	66.95	28.61	0.10
27.5	4.88	1.21	6.69	103.19	21.15	0.18
32.5	7.50	1.73	7.72	139.59	18.61	0.23
37.5	12.15	2.63	9.32	200.31	16.49	0.32
42.5	17.21	3.58	10.77	259.46	15.08	0.40
47.5	22.53	4.56	12.07	312.66	13.88	0.47
52.5	27.85	5.50	13.25	354.75	12.74	0.53
57.5	32.90	6.34	14.31	382.44	11.62	0.57
62.5	36.61	6.92	15.09	393.77	10.76	0.59
67.5	40.64	7.48	15.99	395.47	9.73	0.60
72.5	43.88	7.87	16.83	385.34	8.78	0.61
77.5	46.38	8.10	17.66	366.21	7.90	0.60
82.5	48.18	8.18	18.48	340.88	7.08	0.58
87.5	49.39	8.14	19.29	312.15	6.32	0.56
92.5	50.21	8.04	20.06	282.93	5.63	0.54
97.5	50.57	7.88	20.76	254.83	5.04	0.52
102.5	50.28	7.65	21.35	228.26	4.54	0.49
107.5	49.24	7.36	21.84	203.47	4.13	0.46
112.5	47.55	6.99	22.19	180.80	3.80	0.42
117.5	45.37	6.57	22.42	160.36	3.53	0.39
122.5	43.33	6.19	22.52	145.43	3.36	0.35
127.5	40.47	5.68	22.57	128.15	3.17	0.32
132.5	37.31	5.13	22.60	111.95	3.00	0.28
137.5	34.57	4.67	22.64	99.05	2.87	0.25

*. a period indicates that the entry was not computable

CLASS 1, COMPOSITION MIXED, *BALSAM*

Age Class	volume (m^3/ha)	basal area (m^2/ha)	avg dbh (cm)	stems/ha	stems/m^3	MAI (m^3/ha/yr)
32.5	8.40	1.91	8.05	151.74	18.06	0.26
37.5	13.13	2.82	9.62	212.37	16.17	0.35
42.5	18.26	3.78	11.04	270.75	14.83	0.43
47.5	23.60	4.75	12.32	322.11	13.65	0.50
52.5	28.89	5.68	13.47	361.49	12.51	0.55
62.5	37.48	7.04	15.28	395.17	10.54	0.60
67.5	41.35	7.57	16.16	394.30	9.54	0.61
72.5	44.44	7.93	16.99	382.14	8.60	0.61
77.5	46.80	8.13	17.82	361.55	7.73	0.60
82.5	48.46	8.18	18.65	335.31	6.92	0.59
87.5	49.58	8.13	19.45	306.26	6.18	0.57
92.5	50.32	8.01	20.20	277.20	5.51	0.54
97.5	50.57	7.84	20.88	249.38	4.93	0.52
102.5	50.13	7.60	21.46	223.14	4.45	0.49
107.5	48.94	7.29	21.92	198.76	4.06	0.46
112.5	47.15	6.91	22.25	176.53	3.74	0.42
117.5	44.89	6.47	22.45	156.52	3.49	0.38
122.5	42.79	6.09	22.53	141.85	3.32	0.35
127.5	39.86	5.57	22.58	124.85	3.13	0.31
132.5	36.64	5.02	22.61	108.75	2.97	0.28
137.5	33.86	4.55	22.66	95.80	2.83	0.25

CLASS 1, COMPOSITION MIXED, *BIRCH*

Age Class	volume (m^3/ha)	basal area (m^2/ha)	avg dbh (cm)	stems/ha	stems/m^3	MAI (m^3/ha/yr)
22.5	3.18	0.87	5.98	79.01	24.85	0.14
32.5	9.31	2.09	8.38	163.90	17.60	0.29
37.5	14.12	3.01	9.92	224.35	15.89	0.38
42.5	19.32	3.97	11.31	281.76	14.58	0.45
47.5	24.67	4.94	12.56	331.08	13.42	0.52
52.5	29.91	5.85	13.69	367.65	12.29	0.57
57.5	33.86	6.50	14.52	386.16	11.40	0.59
62.5	38.32	7.17	15.46	396.04	10.34	0.61
67.5	42.03	7.66	16.33	392.68	9.34	0.62
72.5	44.97	7.98	17.16	378.61	8.42	0.62
77.5	47.18	8.15	17.99	356.66	7.56	0.61
82.5	48.72	8.18	18.81	329.63	6.77	0.59
87.5	49.76	8.11	19.60	300.38	6.04	0.57
92.5	50.42	7.98	20.35	271.53	5.39	0.55
97.5	50.54	7.80	21.01	244.01	4.83	0.52
102.5	49.95	7.54	21.56	218.11	4.37	0.49
107.5	48.63	7.22	21.99	194.14	3.99	0.45
112.5	46.73	6.83	22.30	172.36	3.69	0.42
117.5	44.38	6.38	22.48	152.75	3.44	0.38
122.5	42.23	5.99	22.55	138.35	3.28	0.34
127.5	39.24	5.46	22.59	121.59	3.10	0.31
132.5	35.96	4.90	22.62	105.53	2.93	0.27
137.5	33.15	4.43	22.68	92.53	2.79	0.24

CLASS 1, COMPOSITION MIXED, *BLACK SPRUCE*

Age Class	volume (m^3/ha)	basal area (m^2/ha)	avg dbh (cm)	stems/ha	stems/m^3	MAI (m^3/ha/yr)
2.5	0.00	0.00	2.62	0.00	.	0.00
12.5	0.00	0.00	3.75	6.86	.	0.00
17.5	0.68	0.36	4.88	42.88	63.06	0.04
22.5	4.03	1.04	6.34	91.09	22.60	0.18
27.5	5.75	1.38	7.04	115.31	20.05	0.21
32.5	10.24	2.27	8.70	176.05	17.19	0.32
37.5	15.14	3.20	10.21	236.22	15.60	0.40
42.5	20.38	4.17	11.57	292.45	14.35	0.48
47.5	25.74	5.13	12.79	339.54	13.19	0.54
52.5	30.92	6.02	13.90	373.20	12.07	0.59
57.5	34.80	6.64	14.71	389.28	11.19	0.61
62.5	39.12	7.28	15.64	396.38	10.13	0.63
67.5	42.68	7.74	16.49	390.64	9.15	0.63
72.5	45.47	8.03	17.33	374.77	8.24	0.63
77.5	47.54	8.16	18.15	351.58	7.40	0.61
82.5	48.96	8.17	18.97	323.87	6.61	0.59
87.5	49.93	8.09	19.76	294.53	5.90	0.57
92.5	50.49	7.95	20.49	265.91	5.27	0.55
97.5	50.49	7.75	21.13	238.70	4.73	0.52
102.5	49.74	7.48	21.66	213.15	4.29	0.49
107.5	48.29	7.15	22.07	189.60	3.93	0.45
112.5	46.29	6.74	22.35	168.28	3.64	0.41
117.5	43.87	6.29	22.50	149.06	3.40	0.37
122.5	41.66	5.89	22.56	134.90	3.24	0.34
127.5	38.61	5.36	22.59	118.36	3.07	0.30
132.5	35.27	4.79	22.63	102.30	2.90	0.27
137.5	32.44	4.32	22.69	89.26	2.75	0.24

CLASS 1, COMPOSITION MIXED, *JACK PINE*

Age Class	volume (m^3/ha)	basal area (m^2/ha)	avg dbh (cm)	stems/ha	stems/m^3	MAI (m^3/ha/yr)
2.5	0.00	0.00	3.00	0.00	.	0.00
12.5	0.00	0.03	4.13	18.86	.	0.00
17.5	1.51	0.53	5.25	54.91	36.36	0.09
27.5	6.62	1.56	7.39	127.45	19.25	0.24
32.5	11.19	2.45	9.01	188.20	16.82	0.34
37.5	16.16	3.39	10.49	247.94	15.34	0.43
42.5	21.46	4.36	11.82	302.76	14.11	0.50
47.5	26.80	5.32	13.02	347.43	12.96	0.56
52.5	31.92	6.18	14.11	378.13	11.85	0.61
57.5	35.72	6.78	14.90	391.81	10.97	0.62
62.5	39.90	7.38	15.81	396.18	9.93	0.64
67.5	43.30	7.81	16.66	388.18	8.96	0.64
72.5	45.94	8.07	17.49	370.63	8.07	0.63
77.5	47.87	8.17	18.32	346.32	7.23	0.62
82.5	49.18	8.16	19.13	318.03	6.47	0.60
87.5	50.07	8.06	19.91	288.71	5.77	0.57
92.5	50.55	7.91	20.62	260.34	5.15	0.55
97.5	50.40	7.70	21.24	233.45	4.63	0.52
102.5	49.50	7.42	21.75	208.27	4.21	0.48
107.5	47.93	7.07	22.13	185.16	3.86	0.45
112.5	45.84	6.65	22.39	164.28	3.58	0.41
122.5	41.07	5.78	22.57	131.50	3.20	0.34
127.5	37.97	5.24	22.60	115.15	3.03	0.30
137.5	31.73	4.20	22.71	85.99	2.71	0.23

CLASS 1, COMPOSITION SPRUCE, *ASPEN*

Age Class	volume (m^3/ha)	basal area (m^2/ha)	avg dbh (cm)	stems/ha	stems/m^3	MAI (m^3/ha/yr)
32.5	4.90	1.58	10.23	172.93	35.29	0.15
37.5	9.16	2.28	10.62	218.71	23.88	0.24
42.5	14.39	3.14	11.15	274.37	19.07	0.34
47.5	19.34	3.97	11.79	324.59	16.78	0.41
52.5	23.84	4.71	12.53	365.79	15.34	0.45
57.5	27.80	5.35	13.37	396.31	14.26	0.48
62.5	31.22	5.89	14.29	415.81	13.32	0.50
67.5	34.18	6.32	15.21	424.59	12.42	0.51
72.5	36.67	6.65	16.05	424.52	11.58	0.51
77.5	38.67	6.88	16.76	418.80	10.83	0.50
82.5	40.37	7.05	17.28	410.81	10.18	0.49
87.5	42.16	7.23	17.60	404.14	9.59	0.48
92.5	44.30	7.45	17.74	400.21	9.03	0.48
97.5	46.78	7.69	17.77	396.30	8.47	0.48
102.5	49.37	7.91	17.76	387.57	7.85	0.48
107.5	51.46	8.06	17.74	375.30	7.29	0.48
112.5	53.87	8.18	17.73	352.00	6.53	0.48
117.5	55.52	8.22	17.73	327.84	5.90	0.47
122.5	56.39	8.19	17.70	306.27	5.43	0.46
127.5	56.86	8.10	17.61	281.86	4.96	0.45
132.5	57.01	7.96	17.46	255.42	4.48	0.43
142.5	56.99	7.74	17.20	218.67	3.84	0.40

CLASS 1, COMPOSITION SPRUCE, *BALSAM*

Age Class	volume (m^3/ha)	basal area (m^2/ha)	avg dbh (cm)	stems/ha	stems/m^3	MAI (m^3/ha/yr)
37.5	10.22	2.45	10.72	230.08	22.51	0.27
42.5	15.41	3.31	11.27	285.00	18.49	0.36
47.5	20.28	4.12	11.93	333.63	16.45	0.43
52.5	24.68	4.85	12.69	372.78	15.10	0.47
57.5	28.53	5.47	13.55	401.09	14.06	0.50
62.5	31.84	5.98	14.47	418.39	13.14	0.51
67.5	34.72	6.40	15.38	425.18	12.25	0.51
72.5	37.11	6.70	16.21	423.73	11.42	0.51
77.5	39.02	6.92	16.88	417.25	10.69	0.50
82.5	40.71	7.09	17.36	409.28	10.05	0.49
87.5	42.56	7.27	17.64	403.14	9.47	0.49
92.5	44.78	7.50	17.75	399.61	8.92	0.48
97.5	47.29	7.74	17.77	395.05	8.35	0.49
102.5	49.90	7.95	17.75	384.98	7.72	0.49
107.5	51.96	8.09	17.74	371.33	7.15	0.48
112.5	54.31	8.20	17.73	346.39	6.38	0.48
117.5	55.86	8.22	17.72	320.99	5.75	0.48
122.5	56.58	8.17	17.67	298.41	5.27	0.46
127.5	56.94	8.06	17.57	273.22	4.80	0.45
132.5	57.02	7.90	17.40	246.33	4.32	0.43
142.5	56.99	7.68	17.13	209.40	3.67	0.40

CLASS 1, COMPOSITION SPRUCE, *BIRCH*

Age Class	volume (m^3/ha)	basal area (m^2/ha)	avg dbh (cm)	stems/ha	stems/m^3	MAI (m^3/ha/yr)
32.5	5.97	1.75	10.33	184.41	30.89	0.18
37.5	11.28	2.63	10.82	241.37	21.40	0.30
42.5	16.42	3.48	11.39	295.40	17.99	0.39
47.5	21.21	4.27	12.07	342.32	16.14	0.45
52.5	25.50	4.98	12.86	379.37	14.88	0.49
57.5	29.23	5.58	13.73	405.46	13.87	0.51
62.5	32.45	6.08	14.66	420.60	12.96	0.52
67.5	35.24	6.47	15.56	425.48	12.07	0.52
72.5	37.53	6.75	16.36	422.79	1 1.27	0.52
77.5	39.36	6.95	16.99	415.69	10.56	0.51
82.5	41.06	7.12	17.43	407.87	9.93	0.50
87.5	42.97	7.31	17.67	402.30	9.36	0.49
92.5	45.27	7.55	17.76	399.00	8.81	0.49
97.5	47.81	7.78	17.77	393.62	8.23	0.49
102.5	50.42	7.99	17.75	382.11	7.58	0.49
107.5	52.45	8.12	17.74	367.02	7.00	0.49
112.5	54.74	8.21	17.73	340.51	6.22	0.49
132.5	57.01	7.85	17.34	237.16	4.16	0.43
142.5	57.00	7.63	17.06	200.14	3.51	0.40

CLASS 1, COMPOSITION SPRUCE, *BLACK SPRUCE*

Age Class	volume (m^3/ha)	basal area (m^2/ha)	avg dbh (cm)	stems/ha	stems/m^3	MAI (m^3/ha/yr)
32.5	7.03	1.93	10.42	195.88	27.86	0.22
37.5	12.33	2.80	10.93	252.55	20.48	0.33
42.5	17.41	3.64	11.52	305.50	17.55	0.41
47.5	22.11	4.42	12.22	350.59	15.86	0.47
52.5	26.29	5.11	13.03	385.51	14.66	0.50
57.5	29.92	5.69	13.91	409.39	13.68	0.52
62.5	33.05	6.16	14.84	422.37	12.78	0.53
67.5	35.74	6.53	15.73	425.46	11.90	0.53
72.5	37.93	6.80	16.50	421.65	11.12	0.52
77.5	39.70	6.99	17.09	414.09	10.43	0.51
82.5	41.42	7.16	17.50	406.55	9.82	0.50
87.5	43.40	7.36	17.70	401.56	9.25	0.50
92.5	45.77	7.60	17.76	398.29	8.70	0.49
97.5	48.34	7.83	17.77	391.93	8.11	0.50
102.5	50.94	8.03	17.74	378.91	7.44	0.50
107.5	52.94	8.15	17.73	362.37	6.84	0.49
112.5	55.15	8.22	17.73	334.35	6.06	0.49
117.5	56.15	8.21	17.71	313.81	5.59	0.48
122.5	56.74	8.13	17.64	290.27	5.12	0.46
127.5	56.99	8.01	17.52	264.41	4.64	0.45
132.5	57.00	7.79	17.27	227.93	4.00	0.43
142.5	57.02	7.57	16.99	190.91	3.35	0.40

CLASS 1, COMPOSITION SPRUCE, *JACK PINE*

Age Class	volume (m^3/ha)	basal area (m^2/ha)	avg dbh (cm)	stems/ha	stems/m^3	MAI (m^3/ha/yr)
32.5	8.10	2.10	10.52	207.31	25.59	0.25
37.5	13.37	2.97	11.04	263.55	19.71	0.36
42.5	18.39	3.81	11.65	315.22	17.14	0.43
47.5	22.99	4.57	12.38	358.40	15.59	0.48
52.5	27.06	5.23	13.20	391.14	14.45	0.52
57.5	30.58	5.79	14.10	412.82	13.50	0.53
62.5	33.62	6.24	15.02	423.68	12.60	0.54
67.5	36.22	6.59	15.89	425.12	11.74	0.54
72.5	38.31	6.84	16.63	420.30	10.97	0.53
77.5	40.03	7.02	17.19	412.44	10.30	0.52
82.5	41.78	7.19	17.55	405.29	9.70	0.51
87.5	43.85	7.40	17.72	400.86	9.14	0.50
92.5	46.27	7.64	17.77	397.38	8.59	0.50
97.5	48.86	7.87	17.76	389.90	7.98	0.50
107.5	53.41	8.17	17.73	357.35	6.69	0.50

CLASS 2, COMPOSITION MIXED, *ASPEN*

Age Class	volume (m^3/ha)	basal area (m^2/ha)	avg dbh (cm)	stems/ha	stems/m^3	MAI (m^3/ha/yr)
7.5	0.00	0.00	0.14	0.00	.	0.00
12.5	0.00	0.00	1.15	0.00	.	0.00
17.5	0.00	0.00	2.66	0.00	.	0.00
22.5	0.00	0.00	4.15	11.05	.	0.00
27.5	0.73	0.45	6.01	57.08	78.19	0.03
37.5	2.36	0.98	7.66	110.28	46.73	0.06
42.5	5.16	1.81	9.39	188.08	36.45	0.12
47.5	8.97	2.80	10.75	273.53	30.49	0.19
52.5	11.72	3.44	11.39	323.26	27.58	0.22
57.5	14.78	4.08	11.90	368.36	24.92	0.26
62.5	19.24	4.91	12.43	417.98	21.72	0.31
67.5	25.18	5.85	12.93	459.50	18.25	0.37
72.5	28.69	6.33	13.18	471.54	16.44	0.40
77.5	33.15	6.86	13.53	474.36	14.31	0.43
82.5	38.43	7.41	14.10	462.60	12.04	0.47
87.5	43.40	7.87	14.88	440.46	10.15	0.50
92.5	47.06	8.18	15.63	419.52	8.91	0.51
97.5	49.36	8.36	16.26	401.73	8.14	0.51
102.5	51.85	8.48	17.42	364.13	7.02	0.51
107.5	52.81	8.38	18.56	317.12	6.00	0.49
112.5	52.36	8.12	19.32	273.45	5.22	0.47
122.5	51.26	7.79	19.76	238.12	4.65	0.42
127.5	49.66	7.37	20.09	201.38	4.06	0.39

CLASS 2, COMPOSITION MIXED, *BALSAM*

Age Class	volume (m^3/ha)	basal area (m^2/ha)	avg dbh (cm)	stems/ha	stems/m^3	MAI (m^3/ha/yr)
22.5	0.00	0.10	4.63	22.01	.	0.00
27.5	1.09	0.57	6.45	69.64	63.89	0.04
37.5	2.85	1.13	8.04	124.86	43.81	0.08
42.5	5.85	2.00	9.69	204.90	35.03	0.14
62.5	20.41	5.11	12.54	428.23	20.98	0.33
72.5	29.83	6.47	13.26	473.57	15.88	0.41
77.5	34.23	6.98	13.63	473.16	13.82	0.44
82.5	39.45	7.50	14.24	458.78	11.63	0.48
87.5	44.35	7.95	15.05	435.35	9.82	0.51
92.5	47.89	8.25	15.83	413.92	8.64	0.52
97.5	49.99	8.40	16.49	395.02	7.90	0.51
102.5	52.16	8.47	17.65	355.44	6.81	0.51
107.5	52.81	8.34	18.76	306.66	5.81	0.49
112.5	52.06	8.02	19.48	261.87	5.03	0.46
122.5	50.77	7.66	19.88	225.98	4.45	0.41
127.5	49.06	7.22	20.18	188.97	3.85	0.38
137.5	47.83	6.92	20.35	164.09	3.43	0.35

CLASS 2, COMPOSITION MIXED, *BIRCH*

Age Class	volume (m^3/ha)	basal area (m^2/ha)	avg dbh (cm)	stems/ha	stems/m^3	MAI (m^3/ha/yr)
12.5	0.00	0.00	1.65	0.00	.	0.00
17.5	0.00	0.00	3.16	0.00	.	0.00
22.5	0.06	0.21	5.10	33.31	.	0.00
27.5	1.49	0.70	6.87	82.68	55.49	0.05
37.5	3.37	1.29	8.40	139.96	41.53	0.09
42.5	6.57	2.19	9.97	221.98	33.79	0.15
57.5	15.86	4.29	12.05	382.03	24.09	0.28
62.5	21.60	5.30	12.64	437.60	20.26	0.35
77.5	35.30	7.09	13.73	471.39	13.35	0.46
82.5	40.46	7.60	14.39	454.66	11.24	0.49
87.5	45.28	8.03	15.24	430.18	9.50	0.52
97.5	50.56	8.43	16.72	387.94	7.67	0.52
102.5	52.42	8.47	17.89	346.42	6.61	0.51
137.5	47.21	6.77	20.43	151.64	3.21	0.34

CLASS 2, COMPOSITION MIXED, *BLACK SPRUCE*

Age Class	volume (m^3/ha)	basal area (m^2/ha)	avg dbh (cm)	stems/ha	stems/m^3	MAI (m^3/ha/yr)
7.5	0.00	0.00	0.64	0.00	.	0.00
12.5	0.00	0.00	2.15	0.00	.	0.00
17.5	0.00	0.00	3.65	0.37	.	0.00
22.5	0.39	0.33	5.57	44.99	.	0.02
27.5	1.91	0.84	7.27	96.22	50.38	0.07
37.5	3.93	1.46	8.74	155.56	39.58	0.10
42.5	7.33	2.39	10.25	239.19	32.63	0.17
47.5	9.85	3.01	10.98	290.46	29.49	0.21
52.5	12.71	3.66	11.57	338.94	26.67	0.24
57.5	16.96	4.50	12.19	394.90	23.28	0.29
62.5	22.79	5.49	12.75	445.99	19.57	0.36
67.5	26.36	6.02	13.02	464.61	17.63	0.39
72.5	30.96	6.61	13.35	474.70	15.33	0.43
77.5	36.36	7.20	13.85	469.03	12.90	0.47
82.5	41.46	7.69	14.54	450.23	10.86	0.50
87.5	46.19	8.11	15.43	424.92	9.20	0.53
92.5	48.66	8.31	16.04	408.03	8.39	0.53
97.5	51.06	8.46	16.95	380.45	7.45	0.52
102.5	52.62	8.45	18.12	337.05	6.41	0.51
107.5	52.74	8.28	18.96	295.89	5.61	0.49
112.5	51.70	7.91	19.63	250.10	4.84	0.46
122.5	50.23	7.52	19.99	213.73	4.26	0.41
127.5	48.45	7.07	20.27	176.54	3.64	0.38
137.5	46.60	6.61	20.51	139.21	2.99	0.34

CLASS 2, COMPOSITION MIXED, *JACK PINE*

Age Class	volume (m^3/ha)	basal area (m^2/ha)	avg dbh (cm)	stems/ha	stems/m^3	MAI (m^3/ha/yr)
37.5	4.53	1.63	9.07	171.61	37.88	0.12
42.5	8.13	2.60	10.50	256.40	31.54	0.19
47.5	10.77	3.23	11.19	307.06	28.51	0.23
52.5	13.73	3.87	11.75	353.98	25.78	0.26
57.5	18.09	4.71	12.31	406.88	22.49	0.31
62.5	23.99	5.68	12.84	453.29	18.89	0.38
67.5	27.53	6.18	13.10	468.58	17.02	0.41
72.5	32.06	6.74	13.43	474.91	14.81	0.44
77.5	37.40	7.30	13.97	466.06	12.46	0.48
82.5	42.44	7.78	14.71	445.46	10.50	0.51
97.5	51.49	8.47	17.18	372.49	7.23	0.53
102.5	52.75	8.42	18.34	327.26	6.20	0.51
107.5	52.59	8.20	19.15	284.80	5.42	0.49

CLASS 2, COMPOSITION SPRUCE, *ASPEN*

Age Class	volume (m^3/ha)	basal area (m^2/ha)	avg dbh (cm)	stems/ha	stems/m^3	MAI (m^3/ha/yr)
57.5	5.76	2.02	11.72	211.88	36.78	0.10
62.5	10.08	2.92	12.40	273.06	27.09	0.16
67.5	15.34	4.00	13.22	342.01	22.30	0.23
72.5	19.26	4.74	13.75	383.25	19.90	0.27
77.5	23.98	5.52	14.22	416.89	17.38	0.31
92.5	32.34	6.44	15.71	413.14	12.77	0.35
97.5	33.32	6.39	16.63	394.89	11.85	0.34
102.5	34.88	6.43	17.70	379.03	10.87	0.34
107.5	38.06	6.70	18.26	368.98	9.69	0.35
112.5	42.95	7.20	17.81	364.09	8.48	0.38

CLASS 2, COMPOSITION SPRUCE, *BALSAM*

Age Class	volume (m^3/ha)	basal area (m^2/ha)	avg dbh (cm)	stems/ha	stems/m^3	MAI (m^3/ha/yr)
62.5	11.16	3.15	12.57	287.86	25.79	0.18
67.5	16.35	4.20	13.36	353.73	21.63	0.24
72.5	20.22	4.91	13.86	391.55	19.36	0.28
77.5	24.89	5.66	14.30	421.25	16.92	0.32
82.5	28.28	6.11	14.65	430.57	15.23	0.34
87.5	30.89	6.38	15.11	426.24	13.80	0.35
92.5	32.57	6.43	15.87	409.51	12.57	0.35
97.5	33.54	6.39	16.84	391.37	11.67	0.34
102.5	35.36	6.46	17.87	376.49	10.65	0.34
107.5	38.92	6.78	18.25	367.71	9.45	0.36
112.5	44.04	7.31	17.62	363.15	8.25	0.39
117.5	47.17	7.62	17.05	358.33	7.60	0.40
122.5	49.23	7.75	16.59	345.08	7.01	0.40
127.5	49.64	7.69	16.38	329.37	6.64	0.39
132.5	49.31	7.51	16.24	308.49	6.26	0.37
137.5	48.02	7.11	16.15	271.56	5.66	0.35
142.5	46.90	6.81	16.15	245.23	5.23	0.33

CLASS 2, COMPOSITION SPRUCE, *BIRCH*

Age Class	volume (m^3/ha)	basal area (m^2/ha)	avg dbh (cm)	stems/ha	stems/m^3	MAI (m^3/ha/yr)
57.5	6.85	2.25	11.89	227.46	3.21	0.12
62.5	12.23	3.37	12.74	302.37	24.72	0.20
72.5	21.18	5.08	13.95	399.23	18.85	0.29
77.5	25.78	5.79	14.38	424.97	16.48	0.33
82.5	29.03	6.20	14.75	430.74	14.84	0.35
87.5	31.37	6.41	15.24	423.56	13.50	0.36
92.5	32.78	6.43	16.05	406.01	12.39	0.35
97.5	33.81	6.39	17.06	388.17	11.48	0.35
102.5	35.94	6.51	18.02	374.37	10.42	0.35
107.5	39.86	6.88	18.19	366.79	9.20	0.37
112.5	45.14	7.42	17.43	362.11	8.02	0.40
117.5	48.02	7.69	16.88	355.10	7.39	0.41
132.5	48.96	7.39	16.19	296.70	6.06	0.37

CLASS 2, COMPOSITION SPRUCE, *BLACK SPRUCE*

Age Class	volume (m^3/ha)	basal area (m^2/ha)	avg dbh (cm)	stems/ha	stems/m^3	MAI (m^3/ha/yr)
57.5	7.93	2.47	12.06	242.91	30.63	0.14
62.5	13.28	3.59	12.90	316.37	23.82	0.21
67.5	17.34	4.39	13.50	364.57	21.02	0.26
72.5	22.13	5.23	14.05	406.10	18.35	0.31
77.5	26.65	5.91	14.47	427.86	16.05	0.34
82.5	29.73	6.27	14.86	430.10	14.47	0.36
87.5	31.78	6.43	15.39	420.46	13.23	0.36
92.5	32.97	6.42	16.23	402.47	12.21	0.36
97.5	34.12	6.40	17.29	385.11	11.29	0.35
102.5	36.59	6.56	18.14	372.49	10.18	0.36
107.5	40.86	6.98	18.10	366.01	8.96	0.38
112.5	46.20	7.53	17.23	360.63	7.81	0.41
117.5	48.72	7.74	16.73	350.77	7.20	0.41
122.5	49.54	7.74	16.48	337.97	6.82	0.40
127.5	49.56	7.61	16.30	319.48	6.45	0.39
132.5	48.52	7.26	16.17	284.35	5.86	0.37
137.5	47.48	6.96	16.15	258.49	5.44	0.35
142.5	46.31	6.65	16.15	231.91	5.01	0.32

CLASS 2, COMPOSITION SPRUCE, *JACK PINE*

Age Class	volume (m^3/ha)	basal area (m^2/ha)	avg dbh (cm)	stems/ha	stems/m^3	MAI (m^3/ha/yr)
57.5	9.01	2.70	12.23	258.09	28.64	0.16
62.5	14.32	3.80	13.06	329.56	23.01	0.23
67.5	18.31	4.57	13.63	374.32	20.44	0.27
72.5	23.06	5.38	14.14	411.91	17.86	0.32
77.5	27.49	6.01	14.56	429.66	15.63	0.35
82.5	30.34	6.33	14.98	428.50	14.12	0.37
87.5	32.09	6.44	15.55	416.88	12.99	0.37
92.5	33.14	6.40	16.42	398.67	12.03	0.36
97.5	34.47	6.41	17.50	381.97	11.08	0.35
102.5	37.29	6.62	18.22	370.63	9.94	0.36
107.5	41.89	7.09	17.97	365.07	8.71	0.39

CLASS 3, COMPOSITION SPRUCE, *ASPEN*

Age Class	volume (m^3/ha)	basal area (m^2/ha)	avg dbh (cm)	stems/ha	stems/m^3	MAI (m^3/ha/yr)
32.5	0.00	0.00	9.99	0.00	.	0.00
37.5	0.00	0.00	10.52	0.00	.	0.00
42.5	0.00	0.16	11.09	28.31	.	0.00
47.5	0.80	0.57	11.34	76.00	95.00	0.02
52.5	2.60	1.16	11.14	138.84	53.40	0.05
57.5	5.68	2.00	10.57	219.71	38.68	0.10
67.5	11.64	3.40	9.86	334.38	28.73	0.17
77.5	24.05	5.82	9.70	487.39	20.27	0.31
107.5	57.82	10.84	12.03	628.23	10.87	0.54
112.5	62.65	11.14	13.16	595.32	9.50	0.56
122.5	65.50	10.63	15.35	493.47	7.53	0.53
127.5	64.41	9.86	16.61	415.08	6.44	0.51
137.5	61.26	8.47	18.19	289.67	4.73	0.45

CLASS 3, COMPOSITION SPRUCE, *BALSAM*

Age Class	volume (m^3/ha)	basal area (m^2/ha)	avg dbh (cm)	stems/ha	stems/m^3	MAI (m^3/ha/yr)
37.5	0.00	0.00	10.64	0.00	.	0.00
42.5	0.00	0.23	11.17	36.91	.	0.00
47.5	1.08	0.67	11.34	87.20	80.74	0.02
52.5	3.10	1.30	11.05	153.58	49.54	0.06
57.5	6.49	2.21	10.44	237.90	36.66	0.11
67.5	12.90	3.67	9.79	354.05	27.45	0.19
72.5	18.78	4.85	9.66	431.91	23.00	0.26
77.5	25.95	6.16	9.73	504.90	19.46	0.33
82.5	34.19	7.58	9.94	568.31	16.62	0.41
87.5	40.71	8.62	10.22	605.84	14.88	0.47
92.5	47.08	9.56	10.65	629.97	13.38	0.51
102.5	52.90	10.32	11.27	637.47	12.05	0.52
107.5	59.23	10.95	12.30	621.89	10.50	0.55
112.5	63.50	11.15	13.46	584.09	9.20	0.56
117.5	65.17	11.01	14.38	543.94	8.35	0.55
122.5	65.35	10.46	15.67	474.68	7.26	0.53
127.5	63.96	9.64	16.89	394.49	6.17	0.50
132.5	62.93	9.18	17.44	352.89	5.61	0.47
137.5	60.70	8.24	18.42	268.37	4.42	0.44

CLASS 3, COMPOSITION SPRUCE, *BIRCH*

Age Class	volume (m^3/ha)	basal area (m^2/ha)	avg dbh (cm)	stems/ha	stems/m^3	MAI (m^3/ha/yr)
32.5	0.00	0.00	10.12	0.00	.	0.00
37.5	0.00	0.00	10.77	4.52	.	0.00
42.5	0.12	0.31	11.24	45.93	.	0.00
47.5	1.40	0.78	11.32	99.08	70.77	0.03
52.5	3.66	1.46	10.95	169.09	46.20	0.07
57.5	7.37	2.43	10.31	256.65	34.82	0.13
67.5	14.25	3.95	9.73	373.77	26.23	0.21
72.5	20.46	5.16	9.66	450.82	22.03	0.28
77.5	27.93	6.51	9.77	521.91	18.69	0.36
82.5	36.35	7.93	10.02	582.02	16.01	0.44
87.5	42.88	8.95	10.34	615.59	14.36	0.49
92.5	49.10	9.84	10.84	634.39	12.92	0.53
102.5	54.65	10.52	11.51	636.16	11.64	0.53
107.5	60.51	11.04	12.58	614.28	10.15	0.56
112.5	64.21	11.13	13.76	571.85	8.91	0.57
117.5	65.42	10.91	14.70	528.23	8.07	0.56
122.5	65.12	10.27	15.99	455.28	6.99	0.53
132.5	62.38	8.95	17.69	331.95	5.32	0.47
137.5	60.17	8.00	18.65	247.08	4.11	0.44

CLASS 3, COMPOSITION SPRUCE, *BLACK SPRUCE*

Age Class	volume (m^3/ha)	basal area (m^2/ha)	avg dbh (cm)	stems/ha	stems/m^3	MAI (m^3/ha/yr)
32.5	0.00	0.00	10.25	0.00	.	0.00
37.5	0.00	0.03	10.88	12.17	.	0.00
42.5	0.32	0.39	11.29	55.42	.	0.01
47.5	1.76	0.89	11.28	111.63	63.43	0.04
52.5	4.27	1.63	10.83	185.31	43.40	0.08
57.5	8.32	2.65	10.18	275.82	33.15	0.14
62.5	10.46	3.14	9.95	314.78	30.09	0.17
67.5	15.68	4.24	9.69	393.39	25.09	0.23
72.5	22.22	5.49	9.68	469.38	21.12	0.31
77.5	29.97	6.86	9.81	538.25	17.96	0.39
82.5	38.54	8.28	10.11	594.63	15.43	0.47
92.5	51.04	10.09	11.04	636.93	12.48	0.55
102.5	56.30	10.69	11.76	633.08	11.24	0.55
107.5	61.66	11.11	12.87	605.43	9.82	0.57
112.5	64.77	11.08	14.06	558.51	8.62	0.58
117.5	65.53	10.78	15.03	511.42	7.80	0.56
122.5	64.81	10.07	16.31	435.40	6.72	0.53
127.5	63.46	9.41	17.17	373.74	5.89	0.50
132.5	61.82	8.71	17.94	310.90	5.03	0.47
137.5	59.65	7.76	18.88	225.83	3.79	0.43

CLASS 3, COMPOSITION SPRUCE, *JACK PINE*

Age Class	volume (m^3/ha)	basal area (m^2/ha)	avg dbh (cm)	stems/ha	stems/m^3	MAI (m^3/ha/yr)
32.5	0.00	0.00	10.39	0.00	.	0.00
37.5	0.00	0.09	10.99	20.08	.	0.00
42.5	0.55	0.47	11.32	65.42	.	0.01
47.5	2.16	1.02	11.22	124.87	57.81	0.05
52.5	4.94	1.81	10.70	202.18	40.93	0 09
57.5	9.35	2.89	10.06	295.23	31.58	0.16
67.5	17.19	4.54	9.67	412.76	24.01	0.25
77.5	32.05	7.22	9.87	553.71	17.28	0.41

CLASS 1, COMPOSITION MIXED, All species

Age Class	volume (m^3/ha)	MAI (m^3/ha/yr)
2.5	0.00	0.00
12.5	0.00	0.00
17.5	4.11	0.23
22.5	16.97	0.75
27.5	31.74	1.15
32.5	49.00	1.51
37.5	69.23	1.85
42.5	92.17	2.17
47.5	116.62	2.46
52.5	141.23	2.69
57.5	164.98	2.87
62.5	187.09	2.99
67.5	206.54	3.06
72.5	222.41	3.07
77.5	234.27	3.02
82.5	242.14	2.94
87.5	246.54	2.82
92.5	247.91	2.68
97.5	245.97	2.52
102.5	240.64	2.35
107.5	232.37	2.16
112.5	222.14	1.97
117.5	210.87	1.79
122.5	199.09	1.63
127.5	187.12	1.47
132.5	174.80	1.32

CLASS 1, COMPOSITION SPRUCE, All species

Age Class	volume (m^3/ha)	MAI (m^3/ha/yr)
32.5	35.11	1.08
37.5	60.92	1.62
42.5	85.86	2.02
47.5	109.15	2.30
52.5	130.23	2.48
57.5	148.83	2.59
62.5	165.06	2.64
67.5	179.11	2.65
72.5	190.68	2.63
77.5	199.76	2.58
82.5	207.32	2.51
87.5	214.04	2.45
92.5	219.76	2.38
97.5	223.46	2.29
102.5	224.25	2.19
107.5	222.24	2.07
112.5	217.99	1.94
117.5	211.81	1.80
122.5	203.70	1.66
127.5	194.10	1.52
132.5	182.94	1.38
142.5	170.79	1.20
7.5	0.00	0.00

CLASS 3, COMPOSITION SPRUCE, *JACK PINE*

Age Class	volume (m^3/ha)	basal area (m^2/ha)	avg dbh (cm)	stems/ha	stems/m^3	MAI (m^3/ha/yr)
32.5	0.00	0.00	10.39	0.00	.	0.00
37.5	0.00	0.09	10.99	20.08	.	0.00
42.5	0.55	0.47	11.32	65.42	.	0.01
47.5	2.16	1.02	11.22	124.87	57.81	0.05
52.5	4.94	1.81	10.70	202.18	40.93	0 09
57.5	9.35	2.89	10.06	295.23	31.58	0.16
67.5	17.19	4.54	9.67	412.76	24.01	0.25
77.5	32.05	7.22	9.87	553.71	17.28	0.41

CLASS 1, COMPOSITION MIXED, All species

Age Class	volume (m^3/ha)	MAI (m^3/ha/yr)
2.5	0.00	0.00
12.5	0.00	0.00
17.5	4.11	0.23
22.5	16.97	0.75
27.5	31.74	1.15
32.5	49.00	1.51
37.5	69.23	1.85
42.5	92.17	2.17
47.5	116.62	2.46
52.5	141.23	2.69
57.5	164.98	2.87
62.5	187.09	2.99
67.5	206.54	3.06
72.5	222.41	3.07
77.5	234.27	3.02
82.5	242.14	2.94
87.5	246.54	2.82
92.5	247.91	2.68
97.5	245.97	2.52
102.5	240.64	2.35
107.5	232.37	2.16
112.5	222.14	1.97
117.5	210.87	1.79
122.5	199.09	1.63
127.5	187.12	1.47
132.5	174.80	1.32

CLASS 1, COMPOSITION SPRUCE, All species

Age Class	volume (m^3/ha)	MAI (m^3/ha/yr)
32.5	35.11	1.08
37.5	60.92	1.62
42.5	85.86	2.02
47.5	109.15	2.30
52.5	130.23	2.48
57.5	148.83	2.59
62.5	165.06	2.64
67.5	179.11	2.65
72.5	190.68	2.63
77.5	199.76	2.58
82.5	207.32	2.51
87.5	214.04	2.45
92.5	219.76	2.38
97.5	223.46	2.29
102.5	224.25	2.19
107.5	222.24	2.07
112.5	217.99	1.94
117.5	211.81	1.80
122.5	203.70	1.66
127.5	194.10	1.52
132.5	182.94	1.38
142.5	170.79	1.20
7.5	0.00	0.00

CLASS 2, COMPOSITION MIXED, All species

Age Class	volume (m^3/ha)	MAI (m^3/ha/yr)
12.5	0.00	0.00
17.5	0.00	0.00
22.5	1.23	0.05
27.5	6.35	0.23
37.5	13.59	0.36
42.5	23.50	0.55
47.5	36.38	0.77
52.5	52.45	1.00
57.5	71.43	1.24
62.5	92.66	1.48
67.5	115.17	1.71
72.5	137.71	1.90
77.5	158.91	2.05
82.5	177.62	2.15
87.5	193.34	2.21
92.5	205.81	2.22
97.5	212.95	2.18
107.5	204.66	1.90
112.5	188.58	1.68
122.5	166.02	1.36
127.5	139.63	1.10

CLASS 2, COMPOSITION SPRUCE, All species

Age Class	volume (m^3/ha)	MAI (m^3/ha/yr)
57.5	39.27	0.68
62.5	60.03	0.96
67.5	80.41	1.19
72.5	100.18	1.38
77.5	119.04	1.54
82.5	136.14	1.65
87.5	150.35	1.72
92.5	160.52	1.74
97.5	167.03	1.71
102.5	170.58	1.66
107.5	170.97	1.59
112.5	167.62	1.49
117.5	159.83	1.36
122.5	147.10	1.20
127.5	129.16	1.01
132.5	107.21	0.81
137.5	82.68	0.60

CLASS 3, COMPOSITION MIXED, All species

Age Class	volume (m^3/ha)	MAI (m^3/ha/yr)
32.5	0.00	0.00
37.5	0.00	0.00
42.5	3.15	0.07
47.5	9.60	0.20
52.5	17.79	0.34
57.5	28.39	0.49
62.5	42.05	0.67
67.5	59.13	0.88
72.5	79.45	1.10
77.5	102.52	1.32
82.5	127.50	1.55
87.5	153.25	1.75
92.5	178.35	1.93
102.5	200.89	1.96
107.5	218.10	2.03
112.5	227.11	2.02
117.5	227.08	1.93
122.5	219.56	1.79
127.5	207.06	1.62
132.5	192.19	1.45